Agricultural Sector Models for Policy Analysis

85-4409/

Agricultural Sector Models for Policy Analysis

Editors

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1985

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Foreword

The papers contained in this publication were presented at the Workshop on Agricultural Sector Models held in Ottawa, on October 18-19, 1984. The Workshop was sponsored by the Commodity Markets Analysis Division, Marketing and Economics Branch, Agriculture Canada. Representatives of various federal departments and agencies, the U.S. Department of Agriculture, Canadian and American universities, and the International Institute of Applied Systems Analysis (IIASA) participated in the Workshop.

The objective of the Workshop was to assess the capacity of a number of agricultural sector models to provide quantitative policy analysis, to support the design and evaluation of policies and programs and to identify deficiencies and priorities for future work.

The agricultural industry in Canada and other countries is becoming more complex in structure, markets for agricultural products are becoming increasingly competitive, and budget implications of agricultural programs are coming under increased scrutiny. There is a need to broaden the information base that is used for developing, implementing, and evaluating agriculture policies and programs. It is hoped that this publication will help contribute to proposed solutions by improving policy modeling capacities.

Jack Gellner
Acting Director
Commodity Markets Analysis Division

Acknowledgment

Many people have been helpful in organizing the Workshop and preparing this publication. S. R. Johnson, Professor of Economics and Agricultural Economics, University of Missouri, Columbia, provided valuable input in planning the program for the Workshop. Sean Chin and Zuhair A. Hassan participated very heavily in getting the Workshop going and worked as part of the Organizing Committee.

Reviews by Robert House, U.S. Department of Agriculture; Soe-Lin, Department of Finance Canada; Douglas D. Hedley, Brian Perkins, Brian Davey, Lars Brink, Jim Martin, and Shankar Narayanan, all of Agriculture Canada; and Merele Faminow, Montana State University, appreciably improved the papers.

Thanks are due to Jean-Claude Drapeau for his cooperation in editing the papers, to Bob Lyle for his thorough job of editing the publication, to R. P. Lafrance for drawing the charts, to Andy Trempe and Tina Bow for assisting the Organizing Committee in various tasks, and for supervising the printing and the distribution of the publication, and to all of the staff, such as typists, who helped accomplish our task.

H. Bruce Huff
Chairman, Organizing Committee

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Policy Information Requirements

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*H. Bruce Huff and Jack Gellner**

Introduction

The potential for change in Canadian agricultural policy during the next few years is substantial. This expectation can be traced to a variety of factors. The international and Canadian economic environment has changed dramatically from what it was when much of the existing legislation was introduced. The economic structure embracing Canadian farms, input suppliers and marketing firms continues to adjust rapidly. And a new federal government administration has recently take office. These factors combine with emerging problems of existing programs and the need for policy adjustments perceived by provincial governments, commodity groups and agri-business to create the climate for potential change.

The objectives of this paper are to propose the priorities for new commodity policy analyses arising from the current economic-political environment and to draw implications for commodity policy modeling. These priorities are developed from an evaluation of the medium-term outlook (1985-89) for the international, domestic and agricultural economies. The paper also reviews of policy directions and challenges. Using these analyses, it identifies priorities for new commodity policy information and directions for policy modeling.

Economic environment

The period from the late 1970s to the early 1980s presented many economic difficulties. Most economies suffered from a second major oil price shock, double-digit inflation, high unemployment rates and record high interest rates. The worldwide recession of 1982 was the most severe in 50 years. Many developing countries that depended on commodity exports faced the dilemma of low export prices and rising energy costs and debt repayment obligations.

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*H. Bruce Huff is Director and Jack Gellner is Assistant Director, Policy, Commodity Markets Analysis Division, Agriculture Canada. The statements and conclusions in the paper are those of the authors and do not necessarily reflect the viewpoint of Agriculture Canada.

Since 1982, many OECD countries have had strong recoveries, especially the United States. Real GNP growth in 1984 was substantial in most OECD countries. The forecasts for 1985-89 indicate modest growth, particularly in comparison with the dismal economic performance experienced in the previous 5 to 6 years. For the OECD countries and the United States in particular, the expected moderate growth will likely be accompanied by much lower levels of inflation and declining real interest rates. Unemployment rates and government budget deficits, however, are expected to remain high. Forecasts for the OECD during 1985 and United States during 1985-89 are presented in Tables 1.1 and 1.2.

TABLE 1.1 GROWTH OF REAL GDP/GNP IN THE OECD AREA[a]

			From previous year			From previous half-year				
						1983	1984		1985	
Country	1982 share in total	Average 1972 to 1982	1983	1984	1985	II	I	II	I	II
					(percent)					
United States	40.5'	2.2	3.4	6.00	2.50	7.5	6.50	3.25	2.50	2.50
Japan	14.0	4.3	3.0	4.75	3.75	5.0	5.00	4.00	3.75	4.00
Germany	8.7	2.0	1.3	3.00	2.75	2.3	3.25	2.75	2.50	3.00
France	7.1	2.7	0.7	1.25	1.75	1.0	1.00	1.50	1.75	2.00
United Kingdom	6.3	1.4	3.1	2.50	2.25	2.5	2.00	3.33	2.00	2.00
Italy	4.6	2.6	−2.1	2.25	2.25	1.7	2.50	2.00	2.00	3.00
Canada	3.8	2.8	3.0	4.50	3.00	6.9	3.75	3.50	3.00	2.25
Total above countries	84.9	2.5	2.6	4.50	2.75	5.3	5.00	3.00	2.50	2.75
Other OECD countries	15.1	2.4	1.6	2.75	2.50	3.3	2.50	2.50	2.50	2.50
Total OECD	100.0	2.5	2.4	4.25	2.75	5.0	4.50	3	2.50	2.50

[a]percentage changes from previous period, seasonally adjusted at annual rates

Source: OECD, July 1984

TABLE 1.2 ECONOMIC FORECAST FOR THE UNITED STATES, 1985-89

Variable	1984	1985	1986	1987	1988	1989
			(percent)			
Real GNP	7.5	3.8	1.2	4.8	4.1	2.2
Consumer price index	3.2	4.4	5.5	5.0	5.8	5.5
Moody's corporate bond	13.6	14.1	13.3	11.4	11.2	11.4
Unemployment	7.3	6.4	7.0	6.4	5.7	5.6

Source: Wharton Forecasting, October 2, 1984

World economic growth in the next decade (1984-94) is forecast to remain similar to the experience of the past decade (1974-84), but with lower growth rates in disposable income and employment, according to Wharton's long-term forecast (Table 1.3). Debt repayment problems are most critical in Latin America and, for these countries, growth and import demand will be reduced at least until 1990.

According to the Conference Board of Canada, the economic outlook for Canada for the next 5 years will improve but will not match the performance

TABLE 1.3 WORLD ECONOMIC LONG-TERM FORECAST FOR 10-YEAR AVERAGE GROWTH RATES

Variable	1954-64	1964-74	1974-84	1984-94
		(percent)		
Population	1.7	1.1	1.1	0.9
Civilian labor force	1.4	2.3	2.1	1.3
Employment	1.4	2.3	2.0	1.5
Productivity	2.1	1.3	0.9	1.3
Real GNP	3.6	3.6	2.8	2.8
GNP implicit price deflator	2.0	4.7	6.9	4.8
Real disposable income	3.7	4.0	3.2	2.5
Wage rate (all industries)	4.4	6.7	7.4	6.0
		('000 $US 1972)		
Real per capita disposable income	2.0	2.9	2.1	1.6

Assumptions:
- oil prices growth rate will be moderate over next decade
- high interest rates (Moody "AAA" at 10.7% in 1987, 10.4% in 1991)
- high value of $US will decline over forecast period
- sluggish demand forecast for U.S. and internationally
- U.S. deficit about $200 billion until 1990

Source: Wharton Economic Forecasting, September 1984 of several other OECD countries, especially the United States. Canada will likely experience slower growth in GNP (averaging under 2%) and persistently higher levels of unemployment (above 10%) relative to those in many other developed countries. The federal government deficit is expected to grow by almost 30% between 1984 and 1989. Interest rates in Canada may not fall as quickly as those in the United States. The detailed forecasts for Canada for 1985-89 are presented in Table 1.4.

As a result of the economic recession, debt repayment crises and the increased level of trade restrictions, the international agricultural sector also suffered severe economic hardship. World agricultural commodity prices fell sharply by an estimated 29% between 1980 and 1982 according to the World Bank index of agricultural commodity prices. Commodity surplus stocks increased substantially, especially for grains in the United States and for dairy products in the European Economic Community and the United States. In many cases, explicit or voluntary trade restraints were also introduced.

A number of economic and policy changes have improved the international outlook for agricultural commodities for 1985-89, relative to those

TABLE 1.4 ECONOMIC FORECAST FOR CANADA 1985-89

Variable	1984	1985	1986	1987	1988	1989
Gross national product ($1971, percent)	4.1	0.6	0.4	2.4	2.9	2.2
Consumer price index (1971 = 100, percent)	4.4	3.9	3.6	3.2	4.3	4.4
Unemployment rate (percent)	11.3	11.5	11.7	11.7	11.2	10.4
Real disposable income (percent)	2.3	2.0	0.2	1.5	1.8	2.7
Interest rate (industrial bonds)	14.0	14.3	13.8	12.9	12.3	12.2
Oil prices (Montreal, $/barrel)	36.42	39.34	39.64	39.96	41.91	44.00
Federal government balance ($ bil.)	-27.0	-29.0	-31.5	-32.4	-32.1	-35.0
Current account balance ($ bil.)	2.2	5.0	8.4	10.4	11.6	10.5
Exchange rate (Canada/U.S.)	1.29	1.31	1.30	1.29	1.28	1.27

Source: Conference Board of Canada, October 2, 1984 experienced during the early 1980s. First, a number of countries have introduced measures to limit production. The growth in the nonagricultural sector will both stimulate agricultural demand and reduce supply (by increasing the opportunity cost for resources). Falling real interest rates and more stable energy prices in the short term will improve the balance of payments for many countries. There are also encouraging signs that commodity trade will increase and that international discussions may result in reduced trade restrictions. All of these factors should contribute positively to the level of commodity prices. For the period 1985-90, the World Bank forecasts a 54% increase, in current dollar prices, and a small real price increase for agricultural commodities.

For Canadian agriculture, moderate growth is expected during the 1985-90 period. Grain exports should not be limited by transportation constraints. The beef herd will be in a rebuilding phase and will be reducing its output at least until 1987. Farm cash receipts are expected to grow at about 6%, similar to food price increases in the next 5 years. In both cases, larger increases are anticipated for livestock than for crops. Table 1.5 gives a long-term forecast for Canadian agricultural prices and production.

TABLE 1.5 ECONOMIC FORECAST FOR CANADIAN AGRICULTURE 1984-89

Variable	1984	1985	1986	1987	1988	1989
Prices						
Wheat[a]	203	215	225	240	255	255
Barley[b]	99	108	122	129	131	147
Steers[c]	86	93	104	111	119	125
Hogs[d]	79	84	80	78	91	110
Retail[e]	8.2	5.0	7.4	6.9	7.0	6.7
Production						
Wheat[f]	22	29	28	27	27	29
Barley[f]	11	14	15	15	17	17
Cattle[g]	5.5	5.5	5.7	6.1	6.4	6.8
Hogs[g]	10.3	10.3	10.6	10.8	11.1	11.0
Cash Receipts[e]	4.2	5.3	5.8	6.3	8.5	9.3

[a] export unit value ($/tonne)
[b] off board price ($/tonne)
[c] A1/2 Steers, Toronto ($/cwt)
[d] Index 100, Toronto ($/cwt)
[e] percent change
[f] million tonnes
[g] beginning numbers on farms (mil. head)

Source: Chase Econometrics, July 1984

Policy directions and challenges for Canadian agriculture

Before discussing future directions for agricultural policy, it is helpful to consider briefly the general directions of the recent past. The overall emphasis of recent agricultural policy can be described by four broad objectives:

- — achieving fair and stable returns for producers;
- — providing a stable, reasonably priced and high-quality food supply for Canadian consumers;
- — promoting regional development; and
- — encouraging market development, both in terms of expanding export markets and increasing domestic market shares.

While there is a high degree of complementarity among objectives, there can be a significant degree of conflict. The traditional means of achieving fair and stable returns for producers has been through increased productivity which includes production research, extension and information programs, and quality control. Increased productivity has served producers well in developing Canadian agriculture and has also been quite successful in serving consumer and regional development objectives and in increasing exports.

Income protection and price support programs have also been an important part of Canadian agriculture policy. Programs such as crop insurance, the Agricultural Stabilization Act (ASA), and the Western Grain Stabilization Act (WGSA) have been reasonably effective in serving producer interests and have also tended to be largely complementary to other objectives.

Other agricultural policy thrusts to achieve fair producer returns, however, have been less complementary to other objectives. One example is the establishment of supply management in the dairy and poultry sectors. While undoubtedly serving objectives of increasing producer returns and aiding regional development through cost of production pricing and provincial quota allocations, the interests of consumers and, more particularly, the development of export markets have suffered. In the red meats sector, provincial income stabilization programs have been used to promote regional development objectives but they have also tended to distort regional comparative advantage. Federal-provincial economic development agreements have also served provincial economic development and self-sufficiency objectives without necessarily giving adequate focus fo optimal development from a national perspective.

The overall success of agricultural policy in Canada in achieving its objectives has been mixed. This mixed success reflects the inherent conflict in the objectives. Canada has in general achieved fair returns for producers, provided consumers with stable and high-quality food supplies and protected regional production. In terms of market development, with respect to either export performance or increasing domestic market shares, the success has been much less obvious, especially given the high rates of growth in world trade for many commodities during the last decade. In fact, except for canola and hogs, Canada's export performance has been only adequate at best. Even in the case of wheat and coarse grains, in which considerable export growth has occurred, performance could have been much better were it not for a transportation policy which discouraged investment in the rail transportation system required to support increasing volumes of export sales. The emphasis on market development, which is a relatively recent phenomenon, arose from a realization that greater efforts were needed to promote growth in the agriculture sector through increased exports.

The question now is, What directions in agricultural policy should be followed to meet the challenges of the next decade? As seen above, while the global economy is recovering from the recession of the early 1980s, growth is not expected to return to the levels of the 1970s. Internationally, expectations are for slow economic growth, high unemployment and relatively slow trade growth. The domestic picture is similar, with slow economic growth and high unemployment combined with low population growth. Globally, slow growth and high unemployment will mean continued pressures for measures to protect domestic markets. At the same time, slow growth in trade and foreign exchange requirements will intensify competition and could result in increased use of noncommercial trade practices.

In this environment, international agricultural policy could well be quite volatile, both in terms of trade policies and internal agricultural policies. While international forums are in place to discuss international policy changes, it is essential to have timely and accurate analysis of policy impacts to permit informed and constructive debate. It should be emphasized that these analyses must take account of monetary and fiscal policy impacts as well as agricultural policy impacts. It is only through a clear understanding of interrelationships and interdependencies that increased trade liberalization can be achieved in a difficult economic environment.

In Canada, there is a need to resist demands for more protectionist measures. Growth in agriculture is almost entirely dependent on developing export markets. This means that Canadian products must be competitive in foreign markets. For many commodity sectors, such as those under supply management, this means a shift in market orientation to one that emphasizes market performance and expansion. Implicit in this is a recognition of the importance of respecting regional competitive advantage to achieve low-cost production. Agricultural policy will have to have a strong growth orientation. Agricultural policy developments will also have to recognize and consider continuing structural changes in Canadian agriculture in which the basic farming unit has evolved from the "family farm" to become highly business-oriented and highly dependent on other sectors for markets and inputs.

Slow growth and large government deficits also mean continued restraint in spending and, hence, little potential for new funds for new programs. Greater concentration will have to be paid to reallocating funds within agriculture to finance new initiatives. This will require difficult political and economic decisions which will have to be based on sound analysis of potential benefits against potential costs, both between sectors and between regions.

The foregoing suggests that the base of economic research and policy analysis will have to be expanded. Given a very tight budgetary climate, the research effort must be well coordinated between governments and the private sector to ensure that limited resources are focused on priority problems. Increased focus should be placed on analyzing the impacts of policy changes in other countries, both trade policies and internal agriculture policies. Domestically, the emphasis should be on developing growth-oriented policies which produce viable market opportunities. While continuing current program support, it will be necessary to rationalize national and regional goals, evaluate regional impacts of policy changes, examine structural change and the impacts of expenditure reallocations. The information and analytical tools required for this are examined in the following sections.

Information requirements

From the considerations of the economic outlook and agriculture policy challenges, six areas requiring analysis to provide policy information may be identified.

The highest priority is for information about any ongoing program operations, either existing or new programs. Currently, these include such activities as the support levels for programs like the ASA and WGSA, analysis for supply-managed commodities, and interventions relating to international trade. These programs involve millions of dollars in direct payments to producers and directly affect net farm income.

The second priority is for information on the development of and support to growth-oriented agricultural policies. For the remainder of the 1980s, domestic agricultural and food demand growth will continue to be slow. To achieve a desirable growth rate in agriculture production, a major expansion in net exports will be needed. However, export competition will intensify. In order for Canada to expand exports, it will therefore be important to identify those products and commodities with the greatest comparative advantage both nationally and regionally. There will be a need to provide a good assessment of the effectiveness of programs to improve Canada's comparative advantage, such as biological research and productivity improvement using the Prairie Farm Rehabilitation Administration (PFRA) and Economic and Regional Development Agreements (ERDA). Information will be required on the economic payoff from expenditures to improve production and marketing efficiency, to expand input use and infrastructures, and to provide technical, marketing and market development information.

The third priority for policy information is in the area of international trade negotiations. The agricultural discussions ongoing at the GATT and the OECD, the renewed interest in overall U.S.-Canadian trade, and the continued multilateral discussions for commodity agreements for sugar and grains all point toward substantial changes in trade protection and trading rules. Canada will need to develop its negotiating stance for these future multilateral and bilateral discussions. Negotiations may focus not only on traditional items such as tariffs and import quotas but also on some domestic policies that distort trade. If successful, the increased exposure to international markets will probably increase instability of markets requiring programs to offset these impacts, without increasing trade distortions. One example where better information is required is the impact of alternative domestic commodity stabilization policies on production and hence trade. As well, the implications of agricultural versus industrial tariffs and other trade policies is needed to facilitate any comprehensive negotiations which may be undertaken.

The next priority area is for an examination of the impact of fiscal restraint on agriculture. Agriculture, like other sectors, will be confronted with pressures to make reductions in program costs in order to reallocate funds to higher priorities areas in both the agricultural and nonagricultural sectors. Analysis will be required about the impact of public expenditure reductions on programs such as dairy subsidies, stabilization programs, transportation subsidies, development assistance, research and inspection. Information is needed about the benefits to geographic locations and specific income groups, the macroeconomic benefits, and the agriculture production and trade impacts. Better accountability of programs will create the need to review whether or not they are meeting original objectives. A good means of deriving such quantitative estimates of program objectives will be required.

The fifth area of policy information relates to employment in agriculture. Persistent high unemployment will require continuing assessment of labor requirements of agricultural programs and the employment multipliers from commodity production and processing and from demand expansion activities. The impact of reduced out-migration from agriculture on commodity production, productivity and cost structure will also be important.

Finally, the changing structure of agriculture and food production implies that many of the policies developed during (or prior to) the 1950s and 1960s are no longer relevant for the 1980s. Better information on the current and future commodity industry structure, especially with regard to the income position of producers is needed to assess adequacy of existing policies. A better understanding of the relationship between commodity policy and structural change is required. There will be an ongoing requirement for analysis of modifications to policies in response to evolving economic conditions. Information required will include the impact of changes on treasury costs, producer incomes, retail prices, production responses, trade, and regional incomes.

While setting priorities is essential in order to plan for policy analysis responses to the expected demands of decision makers, it must be recognized that, despite the best efforts to foresee future analytical requirements, there will be unanticipated policy requests which must be answered quickly. Significant policy analysis requests have frequently been made but insufficient resources and time to undertake a thorough assessment are available. The result at times has been incomplete analyses, resulting in less than optimal policy decisions. In order to be more effective, there must be adequate basic analysis available to enable more immediate responses to policy questions.

Role of commodity policy modeling

This section reviews the role that models can play in providing results for the policy information priorities identified in the previous section. Most assessments of the impact of commodity model results on agricultural policy decisions, and consequently their payoff have been descriptive and incomplete. Models have, however, facilitated a more comprehensive and precise analysis, incorporating more factors, longer time periods and more explicit linkages. With these tools it is possible to evaluate a larger set of program options, to provide faster and more precise responses, and to assess the policy impacts through a longer time period.

Agriculture Canada has an extensive involvement in the development, operation and applications of commodity models to analyze significant policy issues (see papers by Huff and Robertson, 1983, and Hassan and Johnson, 1984, for more details on this involvement). Much of this activity occurred during the turbulent 1973-77 period, in which there were rapid changes in domestic commodity markets, foreign commodity policies, and domestic program priorities. An enlarged, well-trained staff was able to respond to policy makers' interests in the analysis of alternative agricultural policies.

As a result, a number of commodity policy models were developed and were used to support a variety of new commodity policy initiatives for such issues as domestic feed grains, grain and livestock transportation, revised grains and general stabilization programs, red meats imports, and regional development programs. As well, other models were constructed to assist in formulating policy positions on international grains reserves, North American livestock trade liberalization, and industrial milk programs.

While there have been many positive contributions from models to policy analysis, there have been some concerns about large development costs and whether model development has been the most optimal resource allocation. A number of suggestions for improved model management have been made. These relate to improving documentation for transfer and continuing use, more adequate resources devoted to continuing maintenance and development, more precise client definition of information requirements, more use of a priori information to reduce estimation requirements, and better project control procedures (see papers by Johnson, Huff and Rauser, 1982, and Hedley and Huff, 1984, for further discussion of these issues).

The role of commodity policy models in the department has diminished in the past 10 years. The economic policy research resources provided have not been sufficient to maintain an adequate level of both model development and maintenance for policy analysis. Nevertheless, the demand for new policy analyses on a wide range of issues continues to be strong.

Summary and conclusion

Governments have an increasing requirement for more comprehensive policy analysis. These expanded requirements can be traced to a variety of factors. First, governments have been playing a more active role in the management of the agricultural economy. This role includes not only the development and monitoring of its own programs but also programs in response to more frequent policy initiatives (or threats) from foreign governments. A second factor is the increasing complexity of the agricultural economy as more factors associated with the rest of the economy influence the agriculture sector and as the linkages become more difficult to identify.

While analysis of alternative marketing strategies and resource allocations have become more sophisticated, producers have become more specialized, thereby increasing their vulnerability to short-run price fluctuations. A fourth factor is the increased accountability by governments for their programs. This requires more ex ante justification of programs and their economic impacts on such variables as employment, trade and fiscal requirements. The policy approval process requires the consent of other ministers with responsibilities for other sectors whose policy proposals may compete directly with those in the agriculture sector for limited government resources. As well, more frequent comprehensive reviews of existing programs and policies will be required on an ongoing basis.

Under current policies, the economic outlook for Canada during the rest of the 1980s is for slow growth, high unemployment, high real interest rates, large government deficits and moderate price increases for the next few years. This will be followed by higher growth rates, improved prices and lower real interest rates, although unemployment and government budget deficits will remain high. The outlook for the agricultural sector indicates modest improvements from rising prices, small input cost increases and a rising level of trade in a highly competitive international market.

Agricultural policy in Canada will have to be reassessed for a number of commodities which have been oriented toward producing for the domestic market. To achieve an adequate level of growth, a more export-oriented approach will be needed. This adjustment will require policies that emphasize trade and productivity improvement. At the same time, restrictive government spending will focus attention on whether existing expenditures are consistent with these objectives.

Given the economic outlook and expected policy directions, the six priority areas for policy analysis identified include information on: support to current programs, growth-oriented policies, trade negotiations, the impact of fiscal restraint, the labor impact of agricultural programs and the changing structure of agriculture. The challenges for specific policy information include such analyses as identifying the impact of public investment on comparative advantage, determining the impact on income distribution and production from reallocation of government expenditures in agriculture and maintaining a broad inventory of up-to-date, quantitive tools for rapid policy responses.

The benefits and resource needs for developing policy models and establishing their priorities require a set of criteria based on a careful consideration of the types of policy information required, the time frame available and the magnitude of the policy impact. Commodity policy models with sufficient lead time for development or modification will be needed for describing complex issues that require economic analysis. As specific types of sector models are discussed in this workshop, there is need to focus on their existing or potential capability and uniqueness to respond to the identified policy information priorities, as well as the resource considerations to refine and/or maintain these models for continuing policy applications.

Given the expected economic and political environment, now is the time to initiate new development activities in commodity policy modeling in order to provide adequate analytical information to policy makers. Additional resources with sufficient long-term commitment must be allocated to this area. Careful planning and control of these resources are needed to ensure that the potential results are achieved.

Appendix: Program support and policy development in agriculture

Program support and policy development place significant demands on the resources of Agriculture Canada. The following is intended to give an overview of some of the support and developmental activities in the department. Included is a brief description of the policy process within government and within Agriculture Canada. An example of the type of requests that are handled in the department is given by reviewing the actual requests of the Grains and Oilseeds Unit of the Commodity Markets Analysis Division. The objective is to provide an inside perspective of the information requirements in the department.

The policy process

In examining the policy process, it is useful to distinguish between two types of policy, the general and the specific. The general provides the overall policy framework for the country as determined by Cabinet, for example, in the area of fiscal policy. The specific provides the sector programs which are determined within the general framework by ministers who have the mandate for given sectors. Ministers, however, must obtain Cabinet approval for their proposals. If new legislation is required or if existing legislation is to be amended, a formal memorandum to Cabinet must be prepared. The specific format of Cabinet documents has tended to change from time to time, but the essential elements include the background to the issue, policy options along with an assessment of advantages and disadvantages, recommendations, financial implications, and implications for related policies.

The preparation of memoranda to Cabinet is initiated by ministers and is based on their instructions, but the responsibility to undertake the necessary analysis to develop policy options and to assess implications is delegated to departmental officials. Interdepartmental consultations are required before a memorandum is finalized; these include representatives from all departments interested in a given proposal.

The documents are first considered by Cabinet committee and, once approved, are confirmed by full Cabinet. Cabinet committee approval also determines the financial allocation for the proposal. The proposal may receive funding either from the "policy reserve," which provides for the financing of new or enriched programs, or from within a department's existing financial allocation. Once a decision is confirmed, legislation is drafted and must be passed through Parliament to attain legal status.

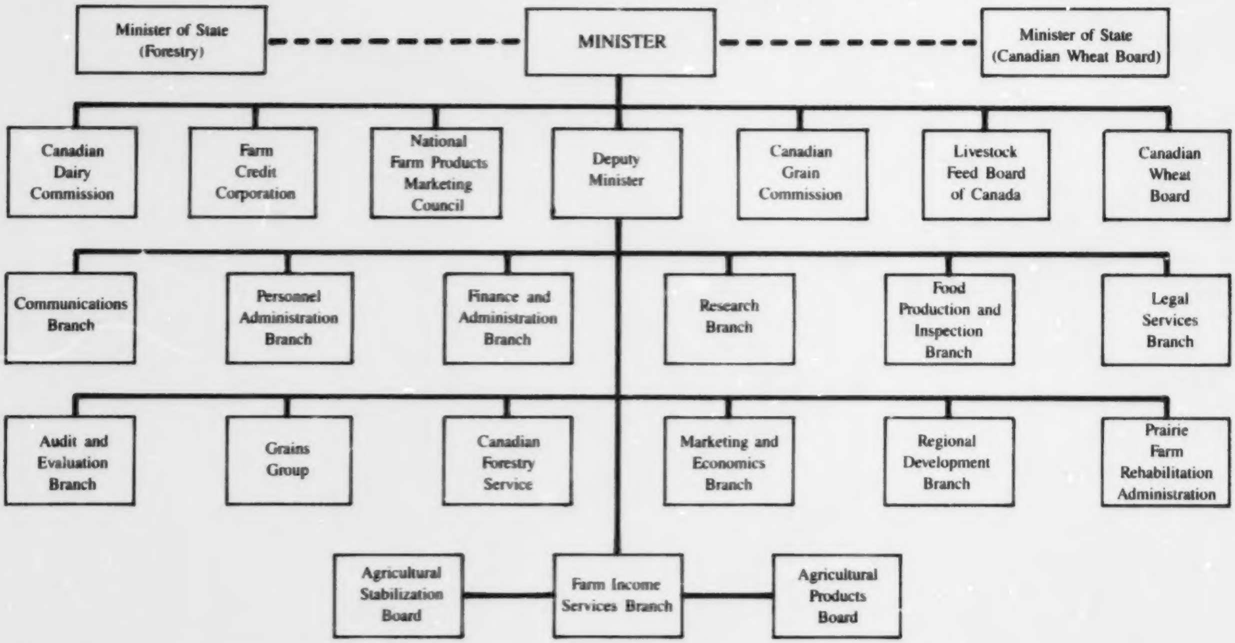
There is a second means of implementing program changes within existing legislation and that is through orders-in-council. Orders-in-council do not normally require consideration by Cabinet committees. They are primarily used to facilitate the administration of acts or to adjust the regulations associated with an act.

Program support and policy development in Agriculture Canada

In Agriculture Canada, the responsibilities for program support are fairly clear-cut with the handling of specific programs being undertaken for the most part within specific branches or crown corporations and agencies (Figure 1.A1). Program support consumes a major portion of Agriculture Canada's resources and presents an ongoing requirement for information and analysis. For example, within the Marketing and Economics Branch, there is a requirement for price support calculations for named and designated commodities under ASA, payout calculations for WGSA, production and import quota analysis for supply-managed commodities, price forecasts for marketing programs, monitoring of benchmark prices for surtax action, and monitoring of beef imports and cheese import prices.

The responsibility for policy development in the department, however, does not neatly fall into particular areas. Issues generally involve more than one branch and often involve a crown agency. Policy issues must therefore be handled on a cooperative basis. Normally, one branch has the lead responsibility for a particular problem. This branch develops a work plan and solicits assistance from other branch agencies as required. For the preparation of a memorandum to Cabinet, for example, the lead branch determines what analysis is required based on the instructions from the minister, identifies the specific activities and the area of responsibility, and seeks approval of the work plan. Depending on the time available for completion of the memorandum, some of the analysis may be contracted to outside analysts to meet deadlines.

Figure 1.A1 AGRICULTURE CANADA ORGANIZATION CHART, November 1984


Minister of State (Forestry)
MINISTER
Minister of State (Canadian Wheat Board)
Canadian Dairy Commission
Farm Credit Corporation
National Farm Products Marketing Council
Deputy Minister
Canadian Grain Commission
Livestock Feed Board of Canada
Canadian Wheat Board
Communications Branch
Personnel Administration Branch
Finance and Administration Branch
Research Branch
Food Production and Inspection Branch
Legal Services Branch
Audit and Evaluation Branch
Grains Group
Canadian Forestry Service
Marketing and Economics Branch
Regional Development Branch
Prairie Farm Rehabilitation Administration
Agricultural Stabilization Board
Farm Income Services Branch
Agricultural Products Board

As a general rule, it is possible to determine which particular issues may arise in a given time period, but the timing is very difficult to predict. Unless an inventory of analysis is available or a strong analytical capability exists, the time available to do a complete analysis is often inadequate.

A brief review of the type of requests that are handled in one commodity area, the Grains and Oilseeds Unit of the Commodity Markets Analysis Division, provides a good example of activities handled in the Marketing and Economics Branch. The activities of the unit also involve providing service to the Minister Responsible for the Canadian Wheat Board, who until recently was not part of the Agriculture portfolio. The common interests of the Minister of Agriculture and the Minister for the CWB are coordinated through the grains group.

A summary of briefing requests in this unit is provided in Table 1.A1 and includes requests over a 21-month period from January 1983 to September 1984. During the period, there was a total of 253 briefing requests. For the most part, these briefings could not be planned for and generally required a very short turnaround. Of the total, 41 were for outlook information for both short and medium terms. Hence, there is a requirement in the unit for ongoing analysis of markets. An additional 41 were requests for comments on Cabinet memoranda prepared by staff in another department covering CWB activities on such issues as initial payment levels and credit grain sales. There were 26 requests to provide background information for ministerial meetings covering a wide range of subjects.

The majority of requests, however, touched on grains policy issues. Of these, feed grain policy requests were the most numerous, reflecting unresolved issues in the domestic feed grain market. The feed grain policy was in fact the subject of an extensive review prior to this period and was done in response to a directive from Cabinet. This review is a prime example of an activity that involved an extensive work plan and required the coordinated efforts of a number of branches in the department, two federal agencies and one other department. In addition, in order to complete the review in the time allowed, outside analysts were contracted to handle several of the tasks.

In other cases, substantive analysis was required for the briefings on Feed Freight Assistance. This was in response to a proposal from a Maritime farm group for increased assistance. The issue involved a joint evaluation of the proposal with the Livestock Feed Board and resulted in the preparation of an order-in-council to adjust rates and to expand eligibility to locally produced grains. Also, the WGSA briefings involved the preparation of a memorandum to Cabinet to amend the program after representations and extensive criticism from producers that the program was not meeting its objectives.

TABLE 1.A1 BRIEFING REQUESTS IN THE GRAINS AND OILSEEDS UNIT, JANUARY 1983 TO SEPTEMBER 1984

Subject	Number
Total requests	253
Situation and outlook	41
Cabinet documents – comments	41
Background – ministerial meetings	26
Policy issues	145
Feed grain policy	43
Feed freight assistance	16
International	24
Western Grain Stabilization Program	9
Crop Information System	9
West coast surcharge	11
Prairie Grain Advance Payments Act	10
Miscellaneous	23

Source: Agriculture Canada, Commodity Markets Analysis Division

The international requests involved briefings on the activities of international organizations or policy developments in other countries, for example, the U.S. Payment-in-Kind program. The briefings on the Crop Information System were in response to the proposal of a new initiative by the branch to develop a satellite/weather crop information system. This task involved developing a detailed project proposal, a system of interdepartmental consultations and the preparation of a submission to Treasury Board for funding. The West Coast Surcharge briefings dealt with a request from a consortium of grain companies to have a surcharge placed on producer marketings at a new terminal to cover short-term operating costs. The Prairie Grain Advance Payments briefings were related to a bill to amend this act.

In addition to these briefings and related requests, the unit also had requests in support of ongoing programs, for example, the support price calculations and marketing programs under the ASA, which provide price guarantees and in turn require market assessments.

All of these requests required responses within a relatively short time period, even in cases when more substantive analysis was warranted. This clearly demonstrates the requirement in the department for information and policy analysis and the need for analytical tools to support commodity policy information requests.

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2

The Annual Food and Agriculture Regional Model

*Gerald Robertson and Eileen Krakar**

Introduction

Large-scale economic modeling has played a significant role in the programs of the Economic Branch of Agriculture Canada. Its history in the department can be segmented into four distinct time periods. Prior to 1972, there was virtually no quantitative economic model development. Between 1972 and 1977, a variety of quantitative modeling approaches were rapidly adopted to both describe and analyze commodity issues. During the period 1977 to 1981, the main thrust in Agriculture Canada was on developing the large-scale econometric forecasting model FARM. Since 1981, most of the modeling activity has been involved with maintaining and operating FARM and developing FARMA.

The Food and Agriculture Regional Model, Annual (FARMA) is a multipurpose system of annual econometric models which have evolved from the various submodels in the Food and Agriculture Regional Model (FARM). FARM is a quarterly econometric model used in producing the official Agriculture Canada short-term forecast and in preparing the outlook publication called Market Commentary. For a more detailed though out-of-date description of FARM, see the Agriculture Canada (1980) technical bulletin. FARM has evolved since then and now contains over 600 equations with an expanded commodity coverage. The FARM staff now also publishes quarterly an internal working document called the FARM Report.

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The general model structure can be described as a commodity production and food marketing system encompassing vertical, spatial and temporal product flows, with simultaneous product substitution in consumption and production. Most of the commodity components by themselves are price equilibrium models, and are linked to the other components through competing, complementary and input commodity prices.

An annual model is sometimes preferred over a quarterly model like the FARM for several cogent reasons. First, the quarterly model's structure may approximate particular circumstances existing at one time period; for example, it may use lagged dependent variables or it may be a linear approximation to a more complicated functional form. Second, the amount of data required is smaller for an annual model than for a quarterly model since by definition a quarterly model requires four observations to every one used in an annual model. Third, fine detail such as variations within a year or regional and commodity disaggregations may not be needed for medium- and long-term projections as for short-term projections. Finally, policy issues are sometimes easier to evaluate using a small simple model rather than a larger complex one, although there are times when disaggregation is necessary to properly examine a policy issue. An example of the latter is the analysis done on changes in methods of payment of compensation for changes in the Crow's Nest Pass grain freight rate, which required a model disaggregated by region.

Description of FARMA

FARMA is an extremely versatile system of sixteen submodels. Any submodel can be separated and run independently or it can be combined with others, in whatever way is appropriate for a forecast or a particular policy issue. Further, any of the submodels can be replaced by a version that is more aggregated or disaggregated by commodity or region so long as all the variables needed by the other submodels with which it is to be run are kept endogenous or can be safely assumed to be exogenous. The interlinkages between the submodels are represented diagrammatically in Figure 2.1.

The FARMA consists of 598 equations. It is set in a calendar-year time frame except for the grain and oilseed submodel which is in a crop-year time frame. A complete listing of the model with comments and a variable cross reference list is given in the FARMA Technical Appendix. For a summary description of the submodels, see Table 2.1.

FIGURE 2.1 THE LINKAGES OF FARMA

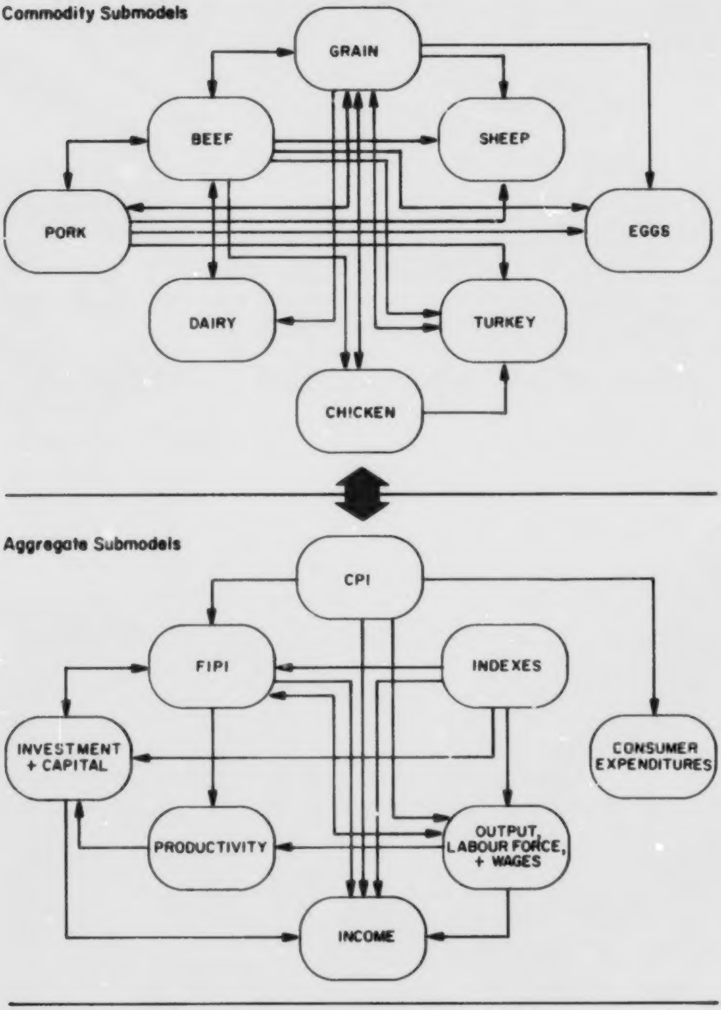

Commodity Submodels
GRAIN
BEEF
SHEEP
PORK
EGGS
DAIRY
TURKEY
CHICKEN
Aggregate Submodels
CPI
FIPI
INDEXES
INVESTMENT + CAPITAL
CONSUMER EXPENDITURES
PRODUCTIVITY
OUTPUT, LABOUR FORCE, + WAGES
INCOME

TABLE 2.1 THE SUBMODELS OF FARMA

Submodel	Description	Size
Commodity submodels		
Grains	*Regions* – Canada, West, East *Commodities* – wheat, barley, oats, rye, corn, soybeans, rapeseed, flaxseed *Scope* – supply, disappearance, inventory, price	100 equations
Beef	*Regions* – Canada, West, East *Commodities* – steers, heifers, bulls and cows, cattle, calves, high- and low-quality beef *Scope* – supply, disappearance, inventory, price	141 equations
Pork	*Regions* – demand: Canada, West, East – supply: Canada, West, Ontario, Quebec, Atlantic *Commodities* – hogs, pork *Scope* – supply, disappearance, inventory, price	49 equations
Eggs	*Regions* – Canada *Scope* – supply, disappearance, inventory, price	10 equations
Chicken	*Regions* – Canada *Commodities* – broilers *Scope* – supply, disappearance, inventory, price	9 equations
Turkey	*Regions* – Canada *Commodities* – heavy and light turkey *Scope* – supply, disappearance, inventory, price	25 equations
Dairy	*Regions* – Canada *Commodities* – disappearance: creamery butter, cheese, all creams, evaporated milk, ice cream, low-fat milk, standard milk, industrial skim milk powder – production: butter, evaporated milk, cheese, ice cream, skim milk powder *Scope* – production, disappearance, government and commercial inventories, target and wholesale prices	61 equations

(continued)

TABLE 2.1 THE SUBMODELS OF FARMA (Concluded)

Submodel	Description	Size
Commodity submodels		
Sheep	*Regions* – Canada *Commodities* – sheep and lamb *Scope* – supply, disappearance, inventory, price	20 equations
Macroeconomic submodels		
Consumer price index	Consumer Price Index (CPI), total food, food at home, food away from home	20 equations
Farm income	Cash receipts, farm expenses, total and realized farm gross and farm net income	46 equations
Farm input price index	Total, animals, crops	31 equations
Productivity in agriculture	Indexes of persons employed, output per person, output per man-hour, unit labor cost	13 equations
Investment and capital in agriculture	Current $ gross fixed capital formation, constant $ gross fixed capital, constant $ net stock of capital, current value of farm capital	26 equations
Output, labor force and wages in agriculture	Employment, labor force, unemployment rate, constant $ GDP agriculture	7 equations
Consumer expenditures	Constant $ personal expenditure and implicit deflators for food, nonfood, food at home, food away from home, total	10 equations
Index numbers of farm prices and production	Total, West, East, crop, livestock	30 equations

Modeling philosophy

A commodity model is, of necessity, a simple approximation of the actual market and considers only a small number of the key relationships. The particular methods chosen in constructing, evaluating and operating this model were considered to be the most appropriate ones given the objectives and the resources available. While the quarterly FARM was designed to serve the traditional clients of the outlook program, the annual FARM was designed to be used for longer-term forecasting and for policy analysis. The variables selected were assumed to have high priority for these uses. An east-west distinction was made for the commodities with significantly different marketing or production systems. Policy makers frequently use aggregate industry statistics to monitor the well-being of agriculture. Variables such as average farm prices, the consumer price index for food, farm incomes and expenditures, and agricultural production were therefore included in FARMA.

FARMA can also be reconfigured with any of the existing models or replaced by smaller or larger ones. In addition, many policy issues may be analyzed using only one of the submodels.

Description of the submodels

The grain and oilseed submodel (FARMAGR) contains two acreage blocks: one for western Canada the other for eastern Canada. Both of these blocks are in the form of multinomial logit models. Complete tables for supply and disposition are specified for some of the crops while only parts are specified for others, depending on the relative economic importance of the crop and the availability and reliability of the data.

In addition, FARMAGR contains price linkage equations which either determine the Canadian grain prices from data on U.S. prices or transform crop-year prices into calendar-year prices.

The beef submodel (FARMABF) explicitly distinguishes between the beef industries in eastern and western Canada. For each region, the inventory of the different animal categories is modeled as well as the flows between these categories. Slaughter and animals traded between the two regions and with the United States is also explained as well as the per capita consumption or disappearance, stocks and net trade of both high- and low-quality beef. Production of the high- and low-quality beef is determined using carcass weight equations. Prices for various categories of the animals in Canada are linked to each other and to U.S. prices.

The pork submodel (FARMAPK) determines inventories of hogs in eastern and western Canada. From this information, it then determines volumes of inspected slaughter plus exports for four different regions. Production of pork in eastern and western Canada is obtained by multiplying by the carcass weight. After per capita disappearance is determined, it is multiplied by population to obtain total disappearance for the two regions. Other equations model stocks and net trade. Hog prices are determined in price transmission equations that link Canadian hog prices to those in the United States.

The egg submodel (FARMAEG) estimates the average producer price using as inputs grain prices and pullet costs. This operation develops the target price within the model using a cost of production formula. Per capita disappearance is estimated and then multiplied by population to get total disappearance. Production is a function of placements, which are also endogenous. Quota for production levels set by the egg marketing board is specified to be a function of disappearance and the quota level from the previous period to represent the supply management system.

The chicken submodel (FARMACK) is similar in structure to the egg model except that quota is exogenous.

The turkey submodel (FARMATK) is also similar to the egg model in structure. Both the light and heavy turkey industries are modeled.

The dairy submodel (FARMADY) explains the disappearance of seven commodities (creamery butter, all creams, evaporated milk, cheese, ice cream, low-fat milk, standard milk and industrial milk) and the production of five (butter, evaporated milk, cheese, ice cream and skim milk powder). Dairy prices and commercial and government inventories are also modeled.

The sheep and lamb submodel (FARMASH) first determines the inventory of lambs and then their marketings. From that, it determines the production of mutton and lamb. Per capita disappearance, stocks and net trade are also explained. The prices of lamb and sheep in Toronto are linked to the unit import values of lamb and sheep.

The submodel for the consumer price index for food (FARMACPI) estimates various consumer price indexes using unit import values. It then weights and aggregates them with the consumer price indexes contained in the individual models to obtain the price for food consumed at home, the price for food eaten away from home, the total food price and finally the total consumer price index (CPI).

The farm income submodel (FARMAINC) adds up the individual commodity cash receipts contained in the other submodels and estimates various components of farm expenses generally as functions of farm input price indexes and some quantity measures. The difference between cash receipts and farm expenses gives realized farm net income. Total farm net income is calculated by developing a value for the inventory change within the model.

The farm input price index submodel (FARMAFIP) esimates the various components of the farm input price index as functions of output prices, input prices and exogenous variables such as exchange rate, oil price, interest rate and wage rate. These components are then weighted and aggregated to get crops, animal production and finally the total farm input price index.

The submodel describing productivity in agriculture (FARMAPRD) calculates indexes for the contribution of agriculture to gross domestic product (GDP), the number of paid workers, average hours worked and persons employed. In general, these agricultural indexes are functions of endogenous variables in the output, labor force and wages submodel.

The submodel for investment and capital in agriculture (FARMAINK) estimates in both constant and current dollars the total gross fixed capital formation for passenger vehicles, farm machinery, farm machinery and equipment, nonresidential construction and commercial vehicles. The components of capital stock in agriculture are estimated using these results, flow identities and the existing capital stock levels.

The output, labor force and wages submodel (FARMAOLW) estimates the number of paid workers and other workers in agriculture, then adds these together to get employment in agriculture. It also estimates the average wages of farm help, the labor force in agriculture and the constant-dollar GDP in agriculture.

In the consumer expenditure submodel (FARMACEX), the total consumer expenditures as well as those for food and nonfood, food consumed at home and food consumed away from home are estimated. Corresponding implicit price deflators are also estimated.

In the farm production and price indexes submodel (FARMAIND), total production and price indexes for crops and livestock are estimated. These are aggregated from the more detailed indexes.

All 16 submodels are linked by variables which are endogenous to one and exogenous to others. The grain model uses farm expenses in the acreage block and livestock prices and inventories or production in the feed demand equations. The beef model uses CPI as a deflator, consumer expenditures and various retail prices in the demand equations, and farm inventories of grain, grain prices, and dairy variables in the supply equations. The pork submodel uses CPI as a deflator and various retail prices in the demand equations and farm inventories of grain, grain prices and beef inventories in the supply equations. The poultry submodels use various retail prices in the demand equations and grain prices in the price and supply equations. The dairy submodel uses CPI as a deflator, various retail prices in the demand equations and grain prices in the supply equations.

Specification

Individual crop acreages in the western Canadian acreage model are assumed to be functions of the supply-inducing price, the cost of production, quota restrictiveness, farm inventories, government programs and trend.

Canadian Wheat Board (CWB) initial prices are used as the supply-inducing prices for wheat and barley, while farm prices received in the quarter prior to planting are used for the other commodities. Cost of production is calculated as total crop expenses per planted acre for the previous crop year divided by the individual crop's three-year moving average yield. The fourth- and first-quarter marketings of the previous crop year are used as proxies for quota restrictiveness.

Most of the key Canadian grain and oilseed prices are specified as the U.S. price times the exchange rate adjusted for local Canadian supply and demand conditions, premiums and/or transportation costs. In some equations, such as for the export price of wheat, the long-term relationship between the Canadian and the U.S. price is imposed. The off-board price of barley at Thunder Bay is estimated using a switching regression to reflect the fact that the CWB initial price tends to set a floor for the off-board price while the CWB domestic price sets a ceiling. If farm inventories are greater than 1.78 million tonnes, then the off-board price is a function of the initial price, CWB adjustment payments and farm inventories; otherwise, it is a function of the corn price and farm inventories. Regression results are contained in Table 2.2.

Deflated or real prices, cross prices and some measure of income are generally used in the demand equations. The per capita disappearance equations all work fairly well (see Table 2.3). The production of most commodities are solved in identities as the product of number of animals times their weight or of acreage times yield. Consequently inventory equations tend to play important roles in determining supply. Unfortunately, however, the inventory equations, especially in the beef submodel, do not work as well as the quarterly versions do in FARM (see Table 2.4).

Since the model is used for medium- and long-term forecasting, it is necessary to develop endogenous policy variables such as the average producer price of chickens and light turkeys, the gross target return for industrial milk and the average farm price of milk (see Table 2.5).

Some of the results for the macroeconomic and aggregate models are presented in Table 2.6. In the equation for the consumer price for food consumed at home (RPFH3), the same weights used in constructing the series are explicitly used in the model. This equation is almost an identity. The equation for cash receipts for other livestock (CROL3) assumes that these receipts are a linear function of cash receipts for livestock, which are explicitly modeled.

TABLE 2.2 PRICE REGRESSION RESULTS

Corn elevator price, Chatham ($/tonne)

$$\mathrm{FPCO2C} = \underset{(2.45)}{6.68} + \underset{(16.42)}{0.96}*\mathrm{PCO4C}*\mathrm{ER34C} - \underset{(-2.30)}{2.70}*\mathrm{QCO3C}$$

$R^2 = 0.98$ dw = 1.98 NOB = 23

Rapeseed price of No. 1 Canada, Vancouver ($/tonne)

$$\mathrm{PRA3C} = \underset{(-3.34)}{-109.15} + \underset{(12.27)}{1.12}*\mathrm{PSO4C}*\mathrm{ER34C} + \underset{(4.20)}{36.82}*\mathrm{PSL4C}/\mathrm{PSM4C}$$

$R^2 = 0.93$ dw = 1.52 NOB = 16

Wheat unit value export price, Canada ($/tonne)

$$\begin{aligned}\mathrm{EXPWH3C} = {} & (1.33 + 0.13*\mathrm{D1980})*(\mathrm{FPWH4C} - \mathrm{XSUWH4C})*\mathrm{ER34C} \\ & + \underset{(3.49)}{16.77}*\mathrm{SUWH4C} - \underset{(-3.41)}{0.59}*\mathrm{EXWH3C}\end{aligned}$$

$R^2 = 0.99$ dw = 1.71 NOB = 17

Barley off-board price, Thunder Bay ($/tonne)

$$\begin{aligned}\mathrm{OPBA3C} = {} & \underset{(6.57)}{52.98} - \underset{(-4.33)}{11.86}*(\text{IF FIBA1C GE 1.78 THEN FIBA1C ELSE 1.78}) \\ & + \underset{(16.72)}{0.76}*\mathrm{XIPBA1C} + \underset{(7.35)}{0.98}*\mathrm{XAPBA1C} \\ & + (\text{IF FIBA1C LT 1.78 THEN } \underset{(-4.34)}{-14.18}*\mathrm{FIBA1C} + \underset{(4.53)}{0.20}*\mathrm{FPCO2C} \text{ ELSE } 0)\end{aligned}$$

$R^2 = 0.99$ dw = 1.90 NOB = 16

TABLE 2.3 DEMAND REGRESSION RESULTS

Per capita disappearance of high-quality inspected beef, Canada (lb)

$$\begin{aligned}\mathrm{PCDHBF3} = {} & \underset{(4.19)}{26.46} + \underset{(1.01)}{55.78}*(\mathrm{CSKFA3}/\mathrm{CSKFD3}) + \underset{(2.99)}{0.01}*(\mathrm{CSKTO3}/\mathrm{POPN3}) \\ & - \underset{(-3.45)}{36.31}*(\mathrm{RPHBF3}/\mathrm{CPI3}) + \underset{(1.12)}{7.91}*(\mathrm{RPLBF3}/\mathrm{CPI3}) \\ & + \underset{(1.48)}{5.65}*(\mathrm{RPPK3}/\mathrm{CPI3})\end{aligned}$$

$R^2 = 0.93$ dw = 1.42 NOB = 17

Per capita disappearance of low-quality inspected beef, Canada (lb)

$$\begin{aligned}\mathrm{PCDLBF3} = {} & \underset{(2.50)}{15.30} + \underset{(5.20)}{0.04}*(\mathrm{CSKFD3}/\mathrm{POPN3}) + \underset{(0.37)}{2.80}*(\mathrm{RPHBF3}/\mathrm{RPFD3}) \\ & - \underset{(-3.92)}{16.44}*(\mathrm{RPLBF3}/\mathrm{RPFD3}) \\ & + \underset{(3.93)}{8.95}*(\mathrm{RPPK3}/\mathrm{RPFD3}) + \underset{(3.13)}{0.23}*\mathrm{PCDLFB3}(-1) - \underset{(-4.27)}{0.64}*\mathrm{UR3}\end{aligned}$$

$R^2 = 0.98$ dw = 1.93 NOB = 16

(continued)

TABLE 2.3 DEMAND REGRESSION RESULTS (Concluded)

Per capita disappearance of pork, Canada (lb)

$$\text{PCDPK3} = \underset{(28.77)}{66.87} - \underset{(-21.13)}{40.03}*(\text{RPPK3/CPI3}) + \underset{(10.73)}{11.47}*(\text{RPLBF3/CPI3})$$

$$+ \underset{(20.68)}{0.25}*(\text{PCDY3/CPI3})$$

$$+ \underset{(3.92)}{0.32}*(\text{RFC3} - (\text{CPI3/CPI3}(-1) - 1)*100)$$

$R^2 = 0.99$ dw = 2.77 NOB = 16

TABLE 2.4 SUPPLY REGRESSION RESULTS

Closing inventory of bull and beef cows, western Canada ('000)

$$(\text{IBW1S} - \text{IBW1S}(-1)) = \underset{(3.26)}{281.86} - \underset{(-11.06)}{1.28}*(\text{DIBW1} + \text{EX1SCT4}) - \underset{(-3.65)}{2.60}*\text{PHF1}(-1)$$

$$+ \underset{(5.57)}{0.68}*\text{IHF1S}(-1)$$

$R^2 = 0.91$ dw = 1.29 NOB = 18

Closing pigs on farms (end of quarter), western Canada ('000)

$$\text{IHG1} = \underset{(0.67)}{351.91} + \underset{(2.27)}{40.47}*(\text{FIOA1C} + \text{FIBA1C} + \text{FIWH1C})$$

$$+ \underset{(1.77)}{13.08}*\text{PHG1}(-1) - \underset{(-1.84)}{7.73}*\text{OPBA1}(-1) + \underset{(5.35)}{0.74}*\text{IHG1}(-1)$$

$R^2 = 0.74$ dw = 2.23 NOB = 19

Hogs, federal and provincial inspected slaughter plus exports, western Canada ('000)

$$\text{SHG1} = \underset{(-0.24)}{-65.69} + \underset{(13.11)}{1.26}*\text{IHG1}(-1)$$

$R^2 = 0.92$ dw = 0.93 NOB = 16

Shipments of milk and cream off farms, Canada (MhL)

$$\text{SMKC3} = \underset{(1.92)}{3.60} + \underset{(35.13)}{3.81}*((\text{IDC3S} + \text{IDC3S}(-1))/2000*\text{SPC3})$$

$R^2 = 0.98$ dw = 0.95 NOB = 23

TABLE 2.5 POLICY ENDOGENIZING EQUATIONS

Average price to producers for broiler chicken, Toronto (¢/kg)

$$\text{XPCK3} = \underset{(3.28)}{15.53} + \underset{(1.63)}{0.14}*\text{FPCO2}(-1) + \underset{(2.20)}{0.08}*\text{PSM2}(-1) + \underset{(4.21)}{0.14}*\text{WA3}$$

$R^2 = 0.95$ dw = 2.10 NOB = 15

Average weighted price for light turkeys to producers, Toronto (¢/kg)

$$\text{XPLT3} = \underset{(0.48)}{3.31} + \underset{(1.52)}{0.19}*\text{FPCO2}(-1) + \underset{(2.05)}{0.11}*\text{PSM2}(-1) + \underset{(5.01)}{0.25}*\text{WA3}$$

$R^2 = 0.95$ dw = 1.96 NOB = 15

(continued)

TABLE 2.5 POLICY ENDOGENIZING EQUATIONS (Concluded)

Gross target returns for industrial milk, Canada ($/hL)

$$\mathrm{XGTM3} = (1-\mathrm{D1975})*(\underset{(-14.54)}{-20.42} + \underset{(23.40)}{1.78}*(\mathrm{XFTM3} + \mathrm{XFTM3}(-1))/2)$$

$$+\ \mathrm{D1975}*(\underset{(-1.20)}{-0.81} + \underset{(49.62)}{1.01}*(\mathrm{XFTM3} + \mathrm{XFTM3}(-1))/2)$$

$R^2 = 0.99$ dw = 0.97 NOB = 18

Average farm price for fluid milk, Canada ($/hL)

$$\mathrm{XPFM3} = \underset{(-2.97)}{-1.20} + \underset{(8.01)}{0.12}*\mathrm{XDCCI2} + \underset{(2.84)}{0.28}*\mathrm{XPFM3}(-1)$$

$R^2 = 0.99$ dw = 0.90 NOB = 18

TABLE 2.6 MACROECONOMIC RESULTS

CPI for food for home consumption, Canada (1981 = 100)

$$\mathrm{LOG}\ (\mathrm{RPFH3}/\mathrm{RPFH3}(-1)) = \underset{(0.41)}{0.00128} + \underset{(28.21)}{1.11}*(5.19*\mathrm{LOG}(\mathrm{RPMT3}/\mathrm{RPMT3}(-1))$$

$$+\ 2.31*\mathrm{LOG}(\mathrm{RPDP3}/\mathrm{RPDP3}(-1)) + 0.29*\mathrm{LOG}(\mathrm{RPEG3}/\mathrm{RPEG3}(-1))$$

$$+\ 1.74*\mathrm{LOG}(\mathrm{RPCL3}/\mathrm{RPCL3}(-1)) + 2.96*\mathrm{LOG}(\mathrm{RPFV3}/\mathrm{RPFV3}(-1))$$

$$+\ 0.35*\mathrm{LOG}(\mathrm{RPFO3}/\mathrm{RPFO3}(-1)) + 0.25*\mathrm{LOG}(\mathrm{RPSG3}/\mathrm{RPSG3}(-1))$$

$$+\ 0.61*\mathrm{LOG}(\mathrm{RPKT3}/\mathrm{RPKT3}(-1)))/15.55$$

$R^2 = 0.98$ dw = 1.51 NOB = 18

Farm cash receipts for other livestock, Canada ($ mil.)

$$\mathrm{CROL3} = \underset{(3.05)}{4.63} + \underset{(51.71)}{0.02}*(\mathrm{CRLP3} - \mathrm{CROL3})$$

$R^2 = 0.99$ dw = 0.69 NOB = 34

FIPI for building repair, Canada (1981 = 100)

$$\mathrm{FIPBRPR3} = \underset{(-0.55)}{-0.16} + \underset{(10.05)}{0.20}*\mathrm{PINRAG3} + \underset{(8.85)}{0.52}*\mathrm{FIPBRPR3}(-1)$$

$R^2 = 0.99$ dw = 1.94 NOB = 22

Persons employed in agriculture, Canada (1971 = 100)

$$\mathrm{EMIAG3A} = \underset{(-0.69)}{-2.40} + \underset{(19.68)}{0.28}*\mathrm{PWIAG3A} + \underset{(30.82)}{0.19}*\mathrm{NPWAG3}$$

$R^2 = 0.99$ dw = 0.85 NOB = 14

Constant and gross fixed capital formation, agriculture, farm machinery ($1971)

$$\mathrm{IMAAGK3A}/\mathrm{KMAAGK3A}(-1) = \underset{(4.74)}{0.14}*\mathrm{LOG}(\mathrm{RDPAG3A})$$

$$\underset{(-2.19)}{-\ 0.05}*\mathrm{LOG}(\mathrm{PMAAG3}/\mathrm{FPIAG3}) - \underset{(4.51)}{0.07}*\mathrm{LOG}(\mathrm{KMAAGK3A}(-1))$$

$$+\ \underset{(6.48)}{0.61}*(\mathrm{IMAAGK3A}(-1)/\mathrm{KMAAGK3A}(-2))$$

$R^2 = 0.81$ dw = 1.21 NOB = 32

(continued)

TABLE 2.6 MACROECONOMIC RESULTS (Concluded)

Current value of farm capital in Canada, implements and machinery ($ mil.)

$$\text{KMACH3A} = \underset{(-1.66)}{-83.74} + \underset{(40.99)}{0.84*\text{KMACH3A}(-1)} + \underset{(13.66)}{1.24*\text{IMEAG3A}}$$

$R^2 = 0.99$ dw = 1.49 NOB = 33

Constant and personal expenditure on food at home, Canada ($1971)

$$\begin{aligned}\text{CSKFH3/CSKFD3} = {} & \underset{(8.55)}{3.49} - \underset{(-6.55)}{0.26*\text{LOG(PCSFH3/PCSFA3)}} - \underset{(-9.21)}{0.30*\text{LOG(CSKFD3)}} \\ & + \underset{(2.35)}{0.01*\text{LOG(RFC3)}} + \underset{(5.68)}{0.03*\text{LOG(URSA3)}} \\ & + \underset{(0.40)}{0.06*\text{CSKFH3}(-1)/\text{CSKFD3}(-1)}\end{aligned}$$

$R^2 = 0.98$ dw = 2.12 NOB = 18

Index numbers of farm prices of agricultural products, total crops, eastern Canada (1971 = 100)

$$\begin{aligned}\text{FPICROP2} = {} & \underset{(8.40)}{0.26*\text{FPCO2}} + \underset{(4.09)}{0.07*\text{PS02}} + \underset{(9.01)}{0.25*\text{FPITB3}} + \underset{(2.40)}{0.10*\text{FPIFR3}} \\ & + \underset{(9.65)}{0.30*\text{FPIVG3}} + \underset{(12.72)}{0.15*\text{FPIPW3}}\end{aligned}$$

$R^2 = 0.99$ dw = 0.68 NOB = 13

Regression results and estimation procedures

Each equation in the model is estimated over the maximum range possible given the available data. The range for estimation periods may be as short as 1976 to 1982 or as long as 1950 to 1983. In general, most equations were estimated between approximately 1966 and 1983.

The regression results presented here were selected using three criteria: the importance of the variable predicted, the quality of the regression results, and their suitability for illustrating the general structure of FARMA.

All equations are estimated using ordinary least squares except for the acreage blocks in the grain and oilseed submodel. These are simultaneously estimated in the form of multinomial logit models to describe decision-making processes used by producers for allocating total area among competing crops.

Multinomial logit models are ideal for this purpose since they constrain the estimated share of the individual crops to sum to the total area. Further, they provide a complete set of own and cross elasticities since the estimated share of each crop is dependent upon all the explanatory variables in the system. These advantages, of course, have to be weighed against their disadvantages, namely, their nonlinearity, the need for simultaneous estimation methods, and the use of a different structural form for estimation versus simulation.

Estimation results of the system of equations for western Canadian acreages appear in Table 2.7 and calculated crop response elasticities are shown in Table 2.8. In general, the smaller the share of the crop, the worse the fit, the higher the own elasticities and the lower the cross elasticities.

Simulation results

The entire FARMA was simulated from 1976 to 1981. Selected simulation results within samples are presented in two tables. Table 2.9 contains the results for important commodity variables and Table 2.10 contains the results for macroeconomic and aggregate variables. In general, the root mean squared percentage errors for key variables like production, disappearance and prices are below 20.

The plots, which are separately available (see Appendix), give another illustration of how well FARMA tracks. The model misses turning points for some of the variables, for example, turkey production. Those variables for which a lot of turning points are missed may indicate areas that require further work. However, since this model is to be used for medium- and long-term projections and for policy analysis, it is not always as important to capture short-run changes as it is to capture the overall direction of change. To be able to do this, the model must have a strong cohesive structural framework. The FARMA appears to be a relatively robust model based on its use to date, but because it is a new model, all of its strengths and weaknesses have yet to be discerned.

Assessment of specification

The demand part of this model appears to forecast fairly well. Some cross price effects, however, are not captured. These equations will have to be adjusted if identification of the cross price effects proves essential for any policy analysis. One approach may be to use some system of demand equations.

The supply side of grains and pork work fairly well, although the summerfallow equation specification is weak and tends to overestimate. The supply side of beef is particularly difficult to capture, as it has been in previous econometric models, while the supply side of the supply-managed commodities is relatively easier to capture with the use of policy variables such as quotas and target prices. Since making these policy variables endogenous for

TABLE 2.7 ESTIMATION RESULTS OF THE MULTINOMIAL LOGIT MODEL FOR WESTERN CANADIAN ACREAGES

	Bread wheat	Durum wheat	Oats	Barley	Rye	Flax-seed	Canola	Summer fallow
Intercept		−1.7852 (15.91)	−0.6802 (−9.33)	−0.7279 (−8.55)	−2.8488 (−26.93)	−1.9841 (−14.11)	−2.1870 (−25.17)	0.09227 (0.81)
Supply − inducing price t, t - 1	0.0055 (7.32)	0.0086 (6.56)	0.0071 (11.42)	0.0103 (16.44)	0.0032 (2.86)	0.0018 (5.38)	0.0052 (14.89)	
CWB final payments t - 2	0.0067 *(7.15)*	0.0026 *(3.19)*						
Cost of production t - 1	*−0.0222* (−11.14)	*−0.0268* (−9.94)	*−0.0279* (−12.25)	*−0.0356* (−11.77)	*−0.0166* (−5.97)	*−0.0114* (−9.44)	*−0.0161* (−10.74)	*−0.3512* (−10.91)
4th + 1st qtr. marketings t - 1	0.0747 (13.22)	0.6960 (5.64)	0.2770 (3.14)	0.2417 (10.82)		0.4109 (1.32)	0.7382 (12.81)	
Closing farm inventories t - 1		−0.4643 (−12.37)			−0.4971 (−1.98)	−1.8368 (−4.27)		
March 31 hog inventories t - 1				2.58E − 05 (1.15)				
Trend t	−0.0020 (−1.13)		−0.0029 (−1.93)					0.0197 (7.07)
LIFT Program t	−0.7387 (−19.90	1.1035 (8.91)	0.7307 (14.90)			1.3155 (10.72)	1.1366 (12.94)	0.8247 (14.33)
LIFT Program t - 1					0.6500 (7.97)		0.3602 (5.62)	

(continued)

TABLE 2.7 ESTIMATION RESULTS OF THE MULTINOMIAL LOGIT MODEL FOR WESTERN CANADIAN ACREAGES (Concluded)

	Bread wheat	Durum wheat	Oats	Barley	Rye	Flax-seed	Canola	Summer fallow
R^2		.6731	.9785	.9719	.5792	.8434	.8464	.9502
SSR		.5251	.0764	.0403	.6711	.7090	.8818	.1093
DW		1.905	0.977	2.254	1.663	2.157	1.636	1.687

t = current crop year
t - 1 = previous crop year

TABLE 2.8 WESTERN CANADIAN CROP ACREAGE RESPONSE ELASTICITIES EVALUATED FOR THE 1983 CROP YEAR

	Bread wheat	Durum wheat	Oats	Barley	Rye	Flax-seed	Canola	Summer fallow
Supply-inducing prices t, t - 1								
Wheat: CWB initial (3rd Q)	0.574	−0.369	−0.369	−0.369	−0.369	−0.369	−0.369	−0.369
Durum: CWB initial (3rd Q)	−0.067	1.379	−0.067	−0.067	−0.067	−0.067	−0.067	−0.067
Oats: off-board (1st Q)	−0.019	−0.019	0.540	−0.019	−0.019	−0.019	−0.019	−0.019
Barley: CWB initial (3rd Q) + off-board (1st Q)	−0.128	−0.128	−0.128	0.833	−0.128	−0.128	−0.128	−0.128
Rye: farm (2nd Q t - 1)	−0.006	−0.006	−0.006	−0.006	0.442	−0.006	−0.006	−0.006
Flaxseed: farm (1st Q)	−0.006	−0.006	−0.006	−0.006	−0.006	0.421	−0.006	−0.006
Canola: farm (1st Q)	−0.106	−0.106	−0.106	−0.106	−0.106	−0.106	1.287	−0.106

CWB final payments t - 2								
Wheat	0.102	−0.066	−0.066	−0.066	−0.066	−0.066	−0.066	−0.066
Durum	−0.003	0.064	−0.003	−0.003	−0.003	−0.003	−0.003	−0.003
Cost of production t - 1								
Crop expenses/acre	0.374	−0.518	−0.048	−0.312	0.955	0.353	0.027	−0.338
Wheat yield (3yr av)	1.774	−1.143	−1.143	−1.143	−1.143	−1.143	−1.143	−1.143
Durum yield (3yr av)	−0.176	3.634	−0.176	−0.176	−0.176	−0.176	−0.176	−0.176
Oats yield (3yr av)	−0.116	−0.116	3.226	−0.116	−0.116	−0.116	−0.116	−0.116
Barley yield (3yr av)	−0.480	−0.480	−0.480	3.125	−0.480	−0.480	−0.480	−0.480
Rye yield (3yr av)	−0.030	−0.030	−0.030	−0.030	2.312	−0.030	−0.030	−0.030
Flaxseed yield (3yr av)	−0.043	−0.043	−0.043	−0.043	−0.043	2.899	−0.043	−0.043
Canola yield (3yr av)	−0.248	−0.248	−0.248	−0.248	−0.248	−0.248	3.019	−0.248
Marketings t - 1								
Bread wheat (1st + 4th Q)	0.377	−0.243	−0.243	−0.243	−0.243	−0.243	−0.243	−0.243
Durum (1st + 4th Q)	−0.039	0.809	−0.039	−0.039	−0.039	−0.039	−0.039	−0.039
Oats (1st + 4th Q)	−0.002	−0.002	0.046	−0.002	−0.002	−0.002	−0.002	−0.002
Barley (1st + 4th Q)	−0.109	−0.109	−0.109	0.710	−0.109	−0.109	−0.109	−0.109
Flaxseed (1st + 4th Q)	−0.001	−0.001	−0.001	−0.001	−0.001	0.066	−0.001	−0.001
Rapeseed (1st + 4th Q)	−0.068	−0.068	−0.068	−0.068	−0.068	−0.068	0.832	−0.068
Closing farm inventories t - 1								
Durum	0.004	−0.074	0.004	0.004	0.004	0.004	0.004	0.004
Rye	0.001	0.001	0.001	0.001	−0.103	0.001	0.001	0.001
Flaxseed	0.003	0.003	0.003	0.003	0.003	−0.217	0.003	0.003
March 31 hog inventories *t* - 1	−0.010	−0.010	−0.010	0.066	−0.010	−0.010	−0.010	−0.010
Trend *t*	−0.706	−0.500	−0.799	−0.500	−0.500	−0.500	−0.500	1.529

TABLE 2.9 SELECTED SIMULATION RESULTS: COMMODITY VARIABLES

	MEAN	ME	RMSE	MPE	RMSPE
OPBA3C	106.50	−1.49	17.61	2.18	17.20
FPCO2C	110.17	−1.45	6.69	−0.50	6.69
EXPWH3C	186.01	0.18	4.07	0.53	2.38
QWH1C	20.17	−0.87	1.62	−4.32	7.89
QWH2C	0.81	−0.04	0.10	−3.19	14.28
QBA1C	10.44	−0.06	1.40	1.38	15.98
QBA2C	0.61	0.01	0.06	2.62	9.62
PSS2	64.94	0.46	0.84	0.93	1.82
OIBF3	2001.93	−53.22	64.21	−2.61	3.11
PCDBF3	99.73	−2.92	3.91	−2.72	3.60
PHG2	64.71	−0.40	2.09	−0.60	3.07
QPK3	1412.62	−17.97	82.16	−0.07	5.70
PCDPK3	57.03	−0.05	0.78	0.01	1.27
XPEG3	78.61	−0.36	1.36	−0.32	1.56
SLG3	443.83	2.16	9.36	0.53	2.11
PCDLG3	18.81	0.07	0.31	0.36	1.67
XPCK3	87.31	−0.36	3.31	−0.08	3.57
QCK3	323.14	−0.20	3.83	−0.13	1.27
PCDCK3	13.56	−0.01	0.61	0.10	4.29
XPTK3	118.67	−4.97	5.63	−4.24	4.86
QTK3	94.71	−1.40	4.39	−1.28	4.42
PCDLT3	1.31	0.08	0.10	5.86	7.47
PCDHT3	2.68	−0.01	0.14	−0.30	5.13
XPFM3	32.92	−0.22	0.28	−0.62	0.74
SMKC3	70.10	2.07	2.38	2.99	3.45
PCCB3	4.61	0.10	0.14	2.24	3.02
PCEM3	3.14	0.15	0.55	8.47	18.88
QLA3	13.01	0.65	1.49	6.38	12.19
PSH2	38.62	−2.03	4.88	−4.45	10.44

long-term projections or for policy analysis in other sectors can be difficult, some of them are left exogenous in the FARMA. Most of the models have some sort of price linkage equations. In general, these work very well. In the beef, pork, sheep and grains submodels, price equations specify the Canadian price as a function of the U.S. or world price. In the poultry and dairy submodels, price equations follow the formulas used by the respective agencies.

This typically leaves either trade or stocks to fall out of the identity. As expected, the residual variables tend to be the weakest since they capture all of the errors of the other equations. Some of these equations may be simultaneous if some of the quantity equations has current price as an explanatory variable.

In general, the aggregate submodels use as much structure as possible to weight the individual commodity submodel results. These models tend to work fairly well.

Policy analysis capabilities

The annual Food and Agriculture Regional Model (FARMA) was originally designed for medium- and long-term forecasting and for policy analysis. It has been used for all three. The FARMA was used to prepare the paper on the Medium Term Outlook for Canadian Agriculture which was presented at the December 1983 Outlook Conference and published in Market Commentary: Proceedings of the Canadian Agricultural Outlook Conference, December 1983. The FARMA was also used to prepare a long-term forecast for the paper presented to the Royal Commission on the Economic Union and Development Prospects for Canada, titled A Sectoral View of the Longer Term: Agriculture.

TABLE 2.10 SELECTED SIMULATION RESULTS: MACROECONOMIC AND AGGREGATE VARIABLES

	MEAN	ME	RMSE	MPE	RMSPE
RPFD3	79.95	2.08	2.26	2.82	3.15
RPFH3	76.06	1.31	1.73	1.92	2.54
RPFA3	80.87	5.44	6.14	6.40	7.05
CRT03	13550.00	−157.17	675.56	−0.29	4.28
FEDT03A	10548.00	−221.57	336.23	−1.62	2.54
RFNY3A	3236.56	51.06	467.62	3.25	14.34
FIPI3	76.30	−0.12	1.69	−0.23	2.32
FIPANML3	82.33	−1.01	2.85	−1.45	3.97
FIPCROP3	75.25	−0.27	1.78	−0.03	1.96
EMIAG3A	93.52	−2.17	3.30	−2.27	3.48
QEMIAG3A	118.15	1.87	6.63	1.81	5.85
ULCIAG3A	245.63	10.63	15.34	4.76	6.83
IAG3A	3682.48	−188.58	260.86	−4.50	6.13
KT03A	90210.00	3549.56	6743.33	−2.38	5.81
QAG3	2977.33	−22.41	95.11	−0.63	3.29
EMAG3	476.28	−11.21	16.27	−2.32	3.37
CSKT03	79350.00	−533.63	873.55	−0.70	1.14
PCST03	185.44	0.63	0.98	0.36	0.56
FPIAG3	239.67	0.18	6.41	0.30	2.53
QIT03A	116.58	−4.39	7.63	−3.58	6.34

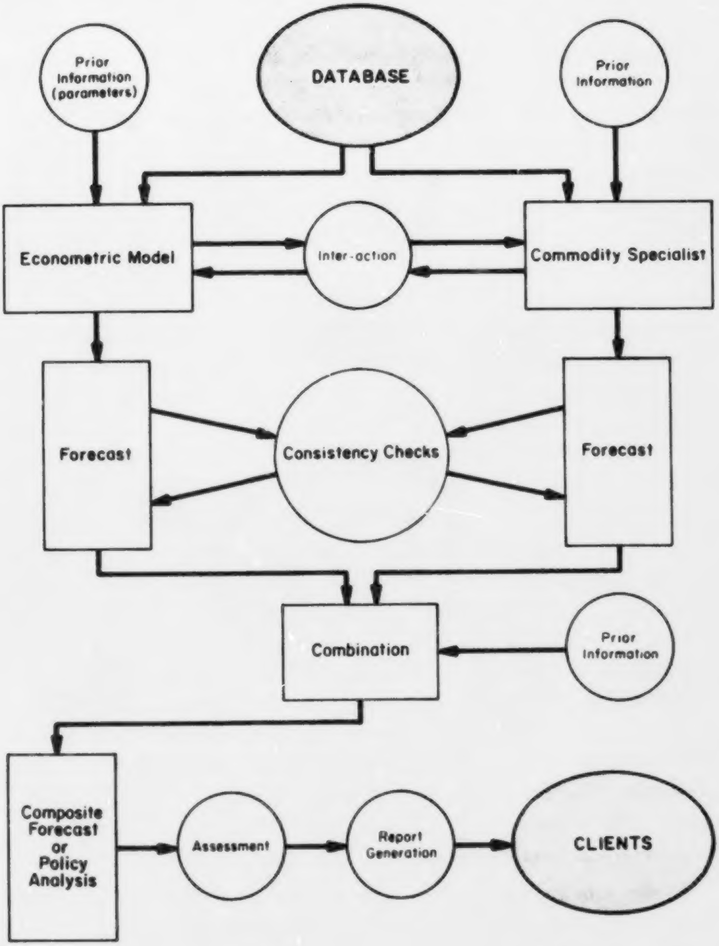
In terms of policy analyses, the FARMA was used in combination with the FARM to provide an analysis of alternative methods of payment of compensation for changes in the Crow's Nest Pass grain freight rate for the Commission of Inquiry set up under the Western Grain Transportation Act. The method which was used can be summarized as follows.

First, the model FARMAGR was simulated to produce an initial 10-year base-run forecast to 1995 for grain prices and production. Results were checked to see if the approximations used in constructing the model were still appropriate for 1995 and for this policy question. These initial results, displayed in annual tables, were distributed to commodity specialists. The commodity specialists then proceeded to analyze and assist in adjusting the model's results to be consistent with their own a priori information and/or knowledge of relevant factors not explicitly accounted for in the model until the final results were achieved (see Figure 2.2). Other models including IIASA's Basic Linked System and linear programming models could also have been used. These final results were fed into both the quarterly and the annual beef and pork models. These models were then used in a similar iterative manner as the FARMAGR model, with commodity specialists to construct a 10-year base-run forecast for beef and pork.

Second, after appropriate changes were made to exogenous variables in the beef and pork models to represent one of the proposed changes in the method of payment, the models were resimulated with the same adjustments used to achieve the base-run forecast. Estimates of the impact of this one particular change to the method of payment were calculated as the differences between the latter run and the base run. This same approach was then taken for each of the other proposed changes to the methods of payment. Third, multipliers were derived for the beef and pork models by simulating them with changes of one unit in selected exogenous variables and comparing the results with those of the base run. Finally, all the results were given to commodity specialists to review, and were compared with analyses done in the past. This ultimately led to the set of results submitted to the Commission of Inquiry investigating the Crow.

This proved to be a valuable exercise since it gave some insight into the strengths and weaknesses of the structure of the beef and pork submodels and identified areas which needed improvement. In general, the pork models are much stronger than the beef models, although both models have trouble explaining east-west trade. However, this is partly due to the nature of the data, because observed east-west trade data are lacking. Consequently, equal per capita disappearance in both the east and west is assumed, and the observed data for all the other items in the balance sheet are used to calculate the east-west trade residually. In the beef model, one of the animal inventories in western Canada grew too fast. These results had to be kept in mind in analyzing the results.

FIGURE 2.2 COMMODITY FORECASTING AND POLICY ANALYSIS SYSTEM DESIGN


Prior Information (parameters)
DATABASE
Prior Information
Econometric Model
Inter-action
Commodity Specialist
Forecast
Consistency Checks
Forecast
Combination
Prior Information
Composite Forecast or Policy Analysis
Assessment
Report Generation
CLIENTS

Potential policy uses

The annual Food and Agricultural Regional Model (FARMA) as it exists today can be used to analyze several policy areas. Parts of the model are suitable for analyzing stabilization policy. For example, the pork model has a structural calculation of stabilization payments. Impact, cumulative delay and long-run multipliers or elasticities needed to examine the impact of these payments on other commodities can easily be calculated for the other submodels. The annual dairy submodel can be used to examine dairy policy. Market share quota and the target return formulas can be run either endogenously or as policy levers. However, the results would be much easier to interpret if the time frame in the submodel was based on the dairy year rather than on the calendar year. Similarly, in the poultry submodels, the quotas and target prices can either be made endogenous or run exogenously. The annual grain submodel can be used to examine the impacts of changes in U.S. policies or of a drought. Linking the grain submodel to the other necessary submodels can develop more aggregated measures such as the consumer price index for food, realized farm net income and the contribution to GDP from agriculture. The entire FARMA can be used to examine the impact on agriculture of changes in macroeconomic variables. In addition, the FARMA could be linked to a macroeconomic model to examine the impact of changes in agriculture on macroeconomic variables.

More generally, this system of models, as with any model, can be used to aid in policy analysis in several ways. First, the data used in the model can be a source of data to the policy analysis. Second, use can be made of the coefficients, multipliers or elasticities of single equations. Third, a submodel or any set of submodels which contain all the appropriate linkages can be used to calculate multipliers or elasticities. The above two methods actually approximate the equation, submodel or model with linear or logarithmic approximations. The final alternative is to solve the equations in the model (or submodel) to find a base run, then change all the exogenous variables needed to represent the new policy, and resimulate. The difference between the two sets of simulation results is then attributed to the policy change. Parts of FARMA have been used in all of these ways.

Summary and conclusion

Various quantitative models, such as econometric and programming models, have been used in the past to analyze policy questions.

These economic models have had an excellent measure of success in influencing the basic elements of the domestic feed grain policy, the Western

Grain Stabilization Act, the industrial milk policy, the Agricultural Stabilization Act, the analysis of the impact of the Soviet grain embargo, and the analyses of the impacts of various methods of payment for grain freight rates (the Crow). As one would expect, the impact of the respective models on policy analysis varies depending upon the policy question being examined and the model concerned. However, there is little doubt that they have contributed to the overall quality of policy analysis in the Marketing and Economics branch.

While FARMA is very new, it adds to the capabilities of the branch to do policy analysis and medium- and long-term forecasting. As it is used for these purposes, its weaknesses will be corrected or strengthened. One of the areas where additional work needs to be done, as mentioned earlier in the paper, is in the east-west trade in beef and pork. Other possible areas for additional work are linkages to a macroeconomic model, development of smaller versions, use demand system results, and research into its structural properties using TROLL's Linear Model Analysis Package (LIMO).

Linking it to a macroeconomic model would afford Agriculture Canada the ability to analyze the effect of changes in agricultural variables on macroeconomic variables. Some of these are modeled in FARM and FARMA. Also, the results from FARM or FARMA can be exogenously fed into a macroeconomic model. Once the two models are linked, the simultaneous interaction of changes in agricultural variables and macroeconomic variables could be examined.

Many policy analyses could benefit from a much smaller version of FARMA. Models are disaggregated to make them work better or to allow the user to see the disaggregation. In cases where the disaggregation is done for the latter reason, the model can be compressed.

As mentioned earlier, some of the demand cross-commodity effects are weak or missing. This could be corrected by using some of the complete demand system results which have been published by Agriculture Canada.

The fourth area where additional work would be useful is research into th structural properties of the model using TROLL's Linear Model Analysis Package (LIMO). This is related to all of the other three areas for additional work, since it would allow a more detailed examination of the interrelationships within the model, including easier calculation of demand and supply elasticities.

Appendix: Data

Time series data on agriculture and other macroeconomic aspects of the economy, stored in computer-readable form is an essential resource to any agricultural model development. The FARMA is supported by a database called FARMBANK which was originally developed to support the FARM. A manual describing this databank in detail is available to the potential user upon request, and arrangements can be made to acquire on-line access to the data or to receive regular update tapes.

Commodity data included in FARMBANK cover grains and oilseeds, beef, pork, poultry and eggs on a Canada basis and for some commodities on an east/west regional basis. The type of information available for each commodity or agricultural product include, where appropriate, price, stocks, production, trade, acreage, yield and so on. In addition, nonagricultural time series or macroeconomic aggregate data are available in FARMBANK, such as interest rates, per capita disposable income and exchange rates. Finally, FARMBANK also encompasses data for the consumer price index, farm income, farm input price index, capital stock and formation, consumer expenditures, productivity, and output, labor force and wages sectors in the model.

The FARMA currently uses approximately 2000 time series which begin, in most cases as far back as 1965. The series are stored in metric units, and are updated mechanically on a semiannual basis. The data supporting FARMA is constructed and maintained from "compacting" the quarterly FARM series. Each data series is extensively commented indicating a detailed source. Major sources include the following:

Agriculture Canada, Market Information Services (MIS)
Statistics Canada, Canadian Socio-Economic Information Management (CANSIM)
Statistics Canada, Dairy Review
Statistics Canada, Dairy Statistics
Statistics Canada, Agriculture Division
Statistics Canada, External Trade Division
Canadian Grain Commission
Canadian Wheat Board
Canadian Dairy Commission
U.S. Department of Agriculture
Food and Agriculture Organization (FAO)
International Monetary Fund (IMF)

Generally speaking, Agriculture Canada is a secondary user of data and may modify them only slightly, usually with respect to units or time period.

However, FARMA data is not problem free. These limitations can be summarized as follows: "missing or incomplete data," "updating problems," "series incompatibility," "periodicity conflict," and "definition problems."

More specifically, the absence of information hampers the incorporation of desired changes to model specifications, or data is simply incomplete over a certain range. Updating problems may arise from a definition change in a portion of the data. This must be compensated by adjusting the remainder of the series manually, and this is not always possible. Updating can also be delayed at the source. In other cases, data is constantly being revised and care must be taken that all variables are changed appropriately. As for "series incompatibility," matching data series can present a problem if, for instance, cash receipts and expenses are not updated at the same time. One of the more inconvenient obstacles arises in trying to make crop, calendar, and dairy years all compatible with the model requirements.

Simultaneous block structure of FARMA

The 598 equation model consists of 450 blocks. There are 441 single equation blocks and 9 blocks containing 157 equations as shown below.

1. the western acreage block (9 equations);
2. the eastern acreage block (5 equations);
3. a large core simultaneous block (118 equations);
4. a flaxseed block (5 equations);
5. an evaporated milk block (2 equations);
6. a cash receipt for crops and other crops block (2 equations);
7. a cash receipt for livestock and other livestock block (2 equations);
8. a farm input price index, output labor force and wages block (12 equations); and
9. a net trade and inventory of lamb block (2 equations).

For a more detailed listing of the block structure, see the FARMA Technical Appendix.

Appendix: Model

A copy of the statistical material, simulation results and point plots for the FARMA model may be obtained free of charge by writing to:

Agriculture Canada
Marketing and Economics Branch
Commodity Markets Analysis Division
930 Carling Avenue
Ottawa, Ontario
K1A 0C5

References

Agriculture Canada. 1978. Commodity forecasting models for Canadian agriculture. Vols. I and II, Ottawa, October.

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3

The Canadian Model in the Basic Linked System of the Food and Agriculture Program of IIASA

*Klaus Frohberg and Günther Fischer**

Introduction

The aim of this paper is to describe the Canadian Agriculture Model (CAM) built by members of the Food and Agriculture Program (FAP) of the International Institute for Applied Systems Analysis (IIASA). The CAM is one of several models constructed by FAP over the last six years. These models are used for policy analysis in an international setting and for this reason are linked together.

Since it is impossible to construct models which allow the analysis of all kinds of policies, we are mainly interested in assessing the impact of those policy instruments which shed some light on the following three broad issues: interdependence of the national food and agriculture systems, growth with equity, and food security. One important issue is always addressed in analyzing these three themes — namely, the hunger problem. Each policy alternative is evaluated also from the point of view of whether it can reduce the number of people in the world who go hungry, or even alleviate their hunger.

Since the CAM is one element in a set of national agricultural policy models, it must adhere to some methodological and mathematical requirements which are imposed on all national models. The following section contains a discussion of the methodological requirements for policy analysis. The linked system as a whole is briefly discussed. We then give a detailed description of the CAM.

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The paper is somewhat unbalanced in the sense that it emphasizes the description of modules for both production and setting of policy instruments at the cost of providing a somewhat shorter overview of the demand module. Space considerations do not permit as explicit a description on the demand side. The estimation procedure applied to the allocation model is dealt with briefly in a later section. The paper ends with a summary on the model characteristics and an accounting of its strengths and weaknesses.

Modeling for policy analysis: The FAP approach

This section discusses some issues which are important from the viewpoint of modeling for policy analysis. After discussing what an ideal approach might be, this section elaborates on the method of tackling the problem in the model.

As already mentioned, the aim of FAP is to analyze alternative policies affecting the food and agriculture system. One aspect of this analysis is the time horizon, which primarily focuses on the medium- and longer-term impacts of agriculture and food policies rather than on their short-term effects.

Because of the increasing interdependency of the national economies in general and their agricultural sector in particular, the small-country assumption cannot be maintained for most of the national policies we are interested in analyzing. A study of national policies that does not appropriately take account of the main links of the country under investigation with the rest of the world is likely to lead to a wrong evaluation for two reasons. First, it is of interest to investigate how the effects of these policies trickle through the worldwide system. The implications of a particular country's policies for other countries must be assessed. Second, it is very likely that feedbacks do occur for the country implementing these policies. Not taking these feedbacks into account would therefore give biased results. It is for those reasons that FAP analyzes alternative policies with a system of linked national agricultural policy models -- called the Basic Linked System (BLS) — covering a large share of the world food and agricultural system.[1]

One of the most common approaches for circumventing the small-country assumption in analyzing national policies is to model the country under investigation explicitly and to represent the rest of the world by an export or import function facing that country. The empirical content of such a net trade function is usually questionable because of the difficulties involved in estimating these functions. Another shortcoming of such an approach is the naive assumption implied in the formulation of these functions that the government policies underlying them are not influenced by world market conditions. The real world shows that many policies are implemented to counterbalance or even to retaliate against policies set into force by other countries. Hence, what is needed is a system of national models with a descriptive representation of the decision-making process on national policies so that there is an active reaction to changes in the economic environment facing the country. Active reaction means a system where, in addition to supply and demand, the level (and kind) of policy instruments also might adjust. It contrasts a model with passive reaction where only supply and demand might change and the policy instruments are not allowed to vary. The model system used for our analysis includes a component where these decision-making processes on policies are represented. The kind of policies which can be analyzed in the model are dealt with in a later section.

The national model must indicate the correct response to changes in policies. Therefore, the economic agents reacting to such policy changes must be represented in a descriptive way. The model system built by IIASA distinguishes three types of economic agents: policy makers, producers and consumers. The latter two can be further classified: consumers can be differentiated by income class, and producers by type of production and/or region. The number of groups of consumers and producers to be identified in a model depends on the characteristics of the country at hand. Clearly, in determining the number of groups, the aggregation error should be minimized. Also, the types of policies to be analyzed affect the grouping, as is discussed below. As usual, however, time, resource and data availability put some limitations on the number of groups together with the operationality requirement.

A model for policy analysis must, of course, identify the relevant policy instruments, and their impact has to be measured by some performance indicators. The current model system handles both international and national policy instruments. Among the former are international buffer stock schemes, trade agreements, compensatory financing, and agreements on market segmentation. On the national level, the instruments are categorized into price and income support policies, trade policies and fiscal policies. The former group comprises a large number of instruments, such as administered price-setting at the producer and/or consumer level, subsidy payments, production quota and so on. Whether these national policies ought to be distinguished by socio-economic and/or spatial stratifications depends on the specific country situation. Of course, modeling requirements increase drastically with the number of subgroups for which policy instruments are analyzed separately.

Although the model may give the impression that only a small subset of all relevant policy instruments are explicitly considered, the majority of the important agriculture and food policies indeed can be handled by the model system. But the set of choices is not exhausted. One of the most limiting factors in enlarging the set of instruments is the operationality of the models. Nothing is gained by increasing the number of instruments and thereby losing operationality. Especially with regard to commodity classification, there is a wide scope for enlarging the models by reducing the heterogeneity of the aggregates. On the other hand, there are parts of the food and agriculture system which are usually not very well modeled because of the difficulties involved in finding an adequate representation. Most noticeably, human capital is often not identified and neither is technological progress satisfactorily specified in policy analysis models. But both factors could contribute to an improvement of the food situation should there be stimulation through new or better policies (such as better education and training or more research).

It may also be argued that the set of instruments chosen for an analysis can always be reduced by classifying groups of instruments with basically the same direction of impact on the system. This might be an effective way to limit the number of instruments to an operational size. Needless to say, the selection and determination of instruments for analysis would be done in close cooperation between modelers, policy advisors and decision makers so as to reflect the special characteristics of a country.

For measuring the impact of policy instruments, a large set of performance indicators can be considered. Usually the policy objectives for which the instruments are used also serve as measures; for example, the impact of an instrument implemented to support farm income may be evaluated by the change in farm income achieved. But a single measure might not be satisfactory for two reasons. First, by choosing a particular (combination of) instrument(s), multiple objectives are often pursued. Second, the side effects of the instruments should not be neglected and might even be very important for the final decision on which instrument is best suited for a particular set of objectives. In the context of FAP's aims, there are some indicators which should always be checked. These are the nutritional status of the people and a welfare indicator. The latter one might be difficult to calculate if it is not possible to specify explicitly a welfare function. Fortunately this is possible for most national models included in FAP's system, because all of them are of the general equilibrium type and because most use a complete demand system which is derived from utility maximization.

It was recognized from the very beginning of the conceptualization of the study that the link between the agricultural and nonagricultural sectors is very important in terms of the results to be obtained for the analysis. Therefore, the national models to be linked into the system must be of the general equilibrium type. Using this approach makes it possible to capture the effects of a policy change on all economic activities, because it ensures that all financial transactions and all quantities balance at the national level.[2]

The balancing conditions state that supply and demand must be equal and that total expenditure cannot exceed total income. Although they are identified from an ex post point of view, they are behavioral equations from an ex ante point of view. And they create a simultaneity among the set of those endogenous variables determined at the same point in time, although a direct link may not even exist.

Analysis of policies can best be done in a dynamic setting because the interest focuses not only on the final state of the system brought about by a policy but also on the adjustment path. Hence, the important time linkages have to be represented in the model. A recursive-dynamic approach is suggested, given the time lag between decisions made on prodution and on consumption. A simultaneous solution of the model over several periods of a prespecified time horizon (dynamic approach) would assume that decision makers (economic agents and politicians) have perfect foresight of future events. Such an assumption, however, is unrealistic. In addition, a dynamic approach would also find its limitations with regard to the operationality of the model. However, this is not to say that an analysis following a recursive-dynamic approach does not require a careful specification of how expectations of the future are formed. Bell and Srinivasan (1983) term a dynamic model without expectations "pseudo-dynamic." According to their view, such a recursive-dynamic model delivers a sequence of short-period solutions through time based on the assumptions that the future will be just like the present.

One of the most critical aspects of constructing models for policy analysis is to allow for an adequate tracking of structural changes. New (or changes in) policies set complex forces into motion which eventually will lead to a different structure of the economy. This is even more important if the analysis is done over a medium time horizon, that is, over a time span in which the production capacity can be augmented or reduced through net investment or disinvestment and in which the labor force is likely to adjust as well. Even the set of technological options might be enlarged should the policy changes be drastic enough, say, in terms of a price change. It can be argued that a strong increase in relative prices would attract additional research capacities to advance the technologies available for producing the commodity which got the economic boost. This, in turn, would reinforce the changes in comparative advantage induced by the price movement. Ideally, the model should have an explicit representation of all structural variables. Since this is almost impossible, various approximations are usually introduced through sophisticated nonlinear functional forms and/or parameter variations. Circumventing the problem of specifying structural variables by using highly nonlinear functions has the disadvantage that it is difficult to say something about the variability of the outcomes associated with a certain policy. For those reasons, Rausser and Just (1982) suggest specifying models which are nonlinear in the parameters rather than in the variables.

The Basic Linked System

Currently, 20 national models are linked into the BLS comprising approximately 80% of the world's total in agricultural production, trade, land availability and population. The remaining part of the global food and agricultural system is divided into 14 regions, each of which is represented by a simplistic model.

Those national models which were built by FAP (including CAM) are based on the Supply Utilization Accounts (SUA) of the United Nations Food and Agriculture Organization (FAO). In addition, FAO's price and fertilizer statistics were used. Data sources other than FAO include macroeconomic statistics of the World Bank and statistical yearbooks of the various countries modeled. The data were checked for inaccuracies as much as the manpower available allowed us to do. Canadian data were especially scrutinized, and revisions of prices had to be made.[3] The advantages of using the SUA is that it represents a consistent data set for all the major countries.

The SUA data had to be further processed to make them suitable for our purpose (see Fischer and Sichra, 1983). Since the most recent SUA data are available to us with a considerable time lag, the years 1961 to 1976 only could be used for setting up the national models.

The national models built by FAP are, in general, all based on the same structure. Of course, attempts were made to get as much advice as possible from country experts.[4] If necessary, country-specific features were included in the models.

To construct a linkable system of national models, some formal requirements must be adhered to by each national model (see Keyzer, 1981). These requirements, however, do not constrain the approach followed to model a country for building a national policy model.

The most obvious requirement is that all nations trade in the same commodities. Ten commodity aggregates have been selected for the international exchange of goods. These commodities are listed in Table 3.1, together with the units of measurement for prices and quantities. These aggregates are defined from a demand point of view so that they may be as homogeneous as possible, given the limit set on the number of commodities traded internationally. Since these aggregates are quite heterogeneous from a production point of view, the allocation module is set up with a different commodity list (see Table 3.14). The highly aggregated commodities of the

TABLE 3.1 COMMODITY LIST OF THE EXCHANGE PART OF THE BLS

Commodity		Dimension	
Number	Name	Quantity	Price (in national currency, nc)
1	wheat	1000 t	$\frac{1000\text{ nc}}{\text{t}}$
2	rice	1000 t milled rice	$\frac{1000\text{ nc}}{\text{milled rice}}$
3	coarse grain	1000 t	$\frac{1000\text{ nc}}{\text{t}}$
4	bovine and ovine meats	1000 t carcass weight	$\frac{1000\text{ nc}}{\text{carcass weight}}$
5	dairy products	1000 t protein equivalent	$\frac{1000\text{ nc}}{\text{milk equivalent}}$
6	other animal products	1000 t protein equivalent	$\frac{1000\text{ nc}}{\text{t protein equivalent}}$
7	protein feed	1000 t protein equivalent	$\frac{1000\text{ nc}}{\text{t protein equivalent}}$
8	other food	U.S. $70 mil.	$\frac{\text{nc}}{\text{U.S. \$70}}$
9	nonfood agriculture	U.S. $70 mil.	$\frac{\text{nc}}{\text{U.S. \$70}}$
10	nonagriculture	U.S. $70 mil.	$\frac{\text{nc}}{\text{U.S. \$ 70}}$

exchange list are other animals (pork, poultry, eggs and fish), protein feed (all meals of crop origin and fish meal and meat meal), other food (oils and fats, sugar, fruit, vegetables and beverages), nonfood agriculture (fibres, wool, industrial products except rubber) and nonagriculture. The latter one is undoubtedly the most heterogenous aggregate, comprising all non-agricultural products.

Another requirement put on the national models is that trading among countries occurs at the same time. This means that the time lag in production between North and South is not considered.

It is assumed that there is a fictitious marketplace where all international trading takes place instantaneously. The BLS is a nonspatial trade model. It generates net trade flows. No information is obtained regarding the origin and destination of trade flows.

It is further required that all national models are homogeneous of degree zero in world market prices. This means that the demand and supply components of a national model must also be homogeneous of degree zero in national prices. The relations between world market prices and domestic prices must be homothetic. In other words, only relative prices matter in the BLS, and monetary factors play a neutral role.

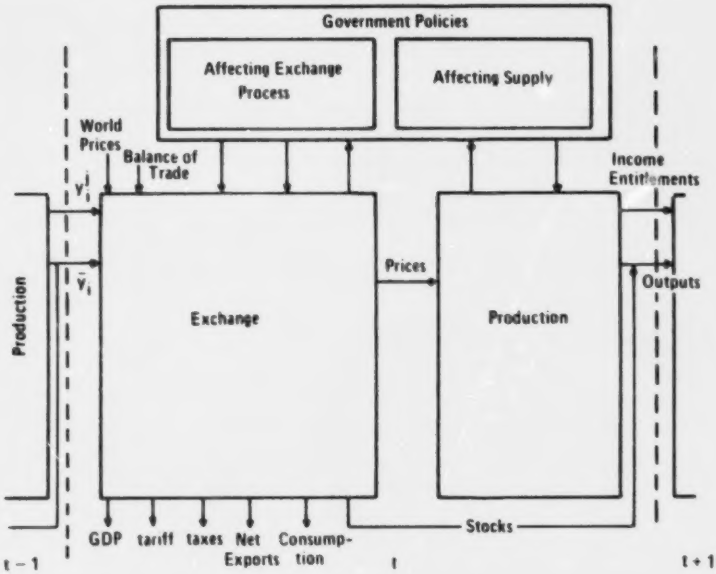
A description of the Canadian agricultural model

A national model linked into FAP's model system consists of the following three parts: the policy module, the supply module, and the demand or exchange module. How the information flows over time from module to module is depicted in Figure 3.1. This figure indicates the recursive-dynamic characteristic of the model. Assume that production is determined in period t - 1. Then the exchange of commodities is solved in interaction with some parts of the policy module in period t taking supply (production plus ending stocks) as given from t - 1. Information on the result of this exchange, noticeably prices, is fed in sequence into the production module. This determines the production level in interaction with the relevant part of the policy module. Production together with ending stocks is used in the following years as endowment for the exchange process.

The policy module

As mentioned earlier, the following national policies are identified in a model: price and income support policies, trade policies and fiscal policies. Among them, only instruments for price policies are currently developed endogeneously. A price transmission equation is specified for each com-

FIGURE 3.1 INFORMATION FLOW AT THE NATIONAL LEVEL


Government Policies
Affecting Exchange Process
Affecting Supply
World Prices
Balance of Trade
Y_i^j
$\bar{Y}_i$
Production
Exchange
Prices
Production
Income Entitlements
Outputs
GDP
tariff
taxes
Net Exports
Consumption
Stocks
t − 1
t
t + 1

modity, determining a target price. It is important to note that the world market price is transmitted to the domestic level via these equations. The equations may also be viewed as setting the rate of an equivalent tariff. It is an equivalent tariff because the prices used to estimate these transmission equations are raw material prices, which are observed at the domestic level, but calculated at the world level. The point is that the domestic prices used in the estimation process are reached by using both tariff and nontariff protection measures. The following functional forms are chosen for the price transmission:

$$praw^{D}_{it} = \alpha_{Pi} * \left[\frac{praw^{E}_{it} - 1}{pw^{E}_{it} - 1}\right]^{\beta_{P10}} * pw^{D}_{it} \quad \text{for } i = 10$$

$$\frac{praw^{D}_{it}}{praw^{D}_{10t}} = \alpha_{Pi} * \left[\frac{pw^{D}_{it}}{pw^{D}_{10t}}\right]^{\beta_{Pi}} * \left[\frac{pw^{E}_{it-1}}{pw^{E}_{10t-1}}\right]^{\gamma_{Pi}} * \left[\frac{praw^{E}_{it-1}}{praw^{E}_{10t-1}}\right]^{\delta_{Pi}} * \left[SSR_{it-1}\right]^{\epsilon_{Pi}}$$

for $i = 1,\ldots,9$

where

$praw_{it}^{D}$ = the desired raw material price of commodity i in year t;
$praw_{it}^{E}$ = the equilibrium raw material price of commodity i in year t;
pw_{it}^{D} = the expected world market price of commodity i in year t (in domestic currency);
pw_{it}^{E} = the equilibrium world market price of commodity i in year t (in domestic currency); and
SSR_{t-1} = self-sufficiency ratio of commodity i in year t.

The parameter values of these equations are given in Table 3.2.[5]

TABLE 3.2 PARAMETER VALUES OF THE PRICE TRANSMISSION FUNCTIONS

Commodity		Parameter values				
Name	Index	α_{pi}	β_{pi}	γ_{pi}	δ_{pi}	ϵ_{pi}
Wheat	$i = 1$	1.02	1.00	0.0	0.0	0.0
Rice	2	0.86	0.27	0.0	0.51	0.0
Coarse grain	3	0.85	1.00	0.0	0.0	0.0
Bovine and ovine meats	4	1.97	0.59	0.1	0.0	−0.5
Dairy products	5	0.56	0.07	0.0	0.52	−0.5
Other animal products	6	4.54	0.28	0.0	0.54	−1.12
Protein feed	7	1.00	0.57	0.0	0.44	0.0
Other food	8	4.19	0.69	0.47	0.0	−1.47
Nonfood agriculture	9	2.41	0.32	0.25	0.0	−0.90
Nonagriculture	10	0.97	0.78	0.0	0.0	0.0

The price transmission equations determine the target price, $praw_t^D$, for each commodity. It is assumed that governments choose target price levels based on the expected world market price for the coming year, the past year's domestic and world market equilibrium prices, and the self-sufficiency level achieved in the past year. The latter one is used only for agricultural commodities. Note that the target price of the nonagricultural commodity enters the transmission equations for agricultural commodities, such that the target prices of the latter are set in relation to that of the nonagricultural aggregate.

The set of price transmission equations can be viewed as presenting the reduced form of the structure of the decision-making process. Because of the availability of limited information only, we could not estimate the structure itself.

The values of the β parameters of the first nine commodities are an indication of the extent to which variations in world market prices are allowed to be transmitted onto the domestic market. As can be seen from Table 3.2, this is most strongly so for wheat and coarse grain, whereas the relative domestic dairy price is almost completely protected from the fluctuations of its counterpart at the world market level.

The β parameters might also be interpreted from the point of view of tariff rates. This rate is defined as the ratio of the domestic price to the corresponding world market price in the current year minus one. The price transmission equation for agricultural commodities can be written as:

$$praw_{it}^{D} = \bar{\alpha}_{pi} * \left[pw_{it}^{D}\right]^{\beta_{pi}}$$

where

$$\bar{\alpha}_{pi} = \alpha_{pi} * \left[pw_{10t}^{D}\right]^{-\beta_{pi}} * \left[\frac{pw_{it-1}^{E}}{pw_{10t-1}^{E}}\right]^{\gamma_{pi}} * \left[\frac{praw_{it-1}^{E}}{praw_{10t-1}^{E}}\right]^{\delta_{pi}} * \left[SSR_{it-1}\right]^{\epsilon_{pi}} * praw_{10t}^{D}$$

The tariff rate, tar_{it}, is obtained by the following expression:

$$tar_{it} = \bar{\alpha}_{pi} * (pw_{it}^{D})^{\beta_{pi-1}}$$

A β value equal to unity indicates that the tariff rate is independent of the level of the current world market prices, whereas β values different from unity make the tariff rate a function of the current world price.

The ϵ parameters may be interpreted as the extent to which the government includes self-sufficiency in its price setting. A value of zero for that parameter indicates that a balance between domestic production and demand is not considered necessary. On the other hand, a high parameter value causes strong price reactions for already small changes in the level of self-sufficiency.

For those price transmission equations for which the parameter γ_{pi} and ϵ_{pi} are equal to zero, it is interesting to look at the long-term elasticity of the world price transmission under the assumption that there is a sustained change between the ith world price and the 10th world market price. The following formula is obtained for t years after the initial year of the price change:

$$\frac{praw_{it}^{D}}{praw_{10t}^{D}} = \alpha_{i}^{\nu_{it}} * \left[\frac{pw_{it-j}^{D}}{pw_{10t-j}^{D}}\right]^{\beta_{pi} * \nu_{it}} * \left[\frac{praw_{it-T}^{E}}{praw_{10t-T}^{E}}\right]^{\delta_{pi}^{T}}$$

where

$$\nu_{it} = \sum_{j=0}^{T-1} \delta_{pi}^{j}$$

$T = t -$ initial year

Under this assumption, we obtain an elasticity, say, $\epsilon_{p_{it}}$, for the price transmission in the year t of the following kind:

$$\epsilon_{p_{it}} = \beta_{pi} * \nu_{it} = \frac{\beta_{pi}(1 - \delta_{pi}^{T})}{1 - \delta_{pi}}$$

If t becomes very large ($t \rightarrow \infty$), then we get:

$$\epsilon_{p_{i\infty}} = \frac{\beta_{pi}}{1 - \delta_{pi}}$$

If β_{pi} and δ_{pi} sum to unity, $\epsilon_{i\infty}$ is unity as well.

In addition to the price transmission equation, stock equations are specified for some commodities in the policy module with the aim to stabilize the world market prices. Since Canada has a relatively open trade, it has an interest in stabilized world market prices. The stocking behavior of the government is modeled with the following principles:

— there are upper and lower bounds on the size of the stocks which are based on past minimum and maximum stock levels;

— changes in the stock level occur only if the relative world market prices deviate between the current and past years; and

— the bounds are reached asymptotically, that is, stock adjustment varies with the price deviation (at a price deviation of 30%, stocks will adjust by 75% of the maximum possible adjustment).

The mathematical specification is as follows:

$$XB_{it} = \begin{cases} XBMIN_i + (\overline{XB}_i - XBMIN_i) * \exp(-\alpha_{it} * Z_{it}) & \text{if } Z_{it} \geq 0 \\ XBMAX_i + (\overline{XB}_i - XBMAX_i) * \exp(\beta_{it} * Z_{it}) & \text{otherwise} \end{cases}$$

with

$$Z_{it} = \frac{pw_{it}^{E}}{pw_{10t}^{E}} - \hat{Z}_{it}$$

$$\hat{Z}_{it} = \frac{pw_{it-1}^{E}}{pw_{10t-1}^{E}}$$

$$\overline{XB}_{it} = XB_{it-1}$$

where

XB_{it} = the level of ending stocks of commodity i in year t;
$\overline{XB}_{it}$ = the level of ending stocks of commodity i in year $t - 1$;
$XBMIN_i$ = minimum ending stock of commodity i;
$XBMAX_i$ = maximum ending stock of commodity i;
Z_{it} = the deviation of the relative world market price of commodity i in year t from its corresponding value in the previous year; and
$\hat{Z}_{it}$ = the relative world market price of commodity i in year $t - 1$.

The parameters α_{it} and β_{it} are specified as:

$$\alpha_{it} = ln \left[\frac{\alpha^*}{\delta_1 * \hat{Z}_{it}} \right]$$

$$\beta_{it} = ln \left[\frac{\alpha^*}{\delta_2 * \hat{Z}_{it}} \right]$$

where

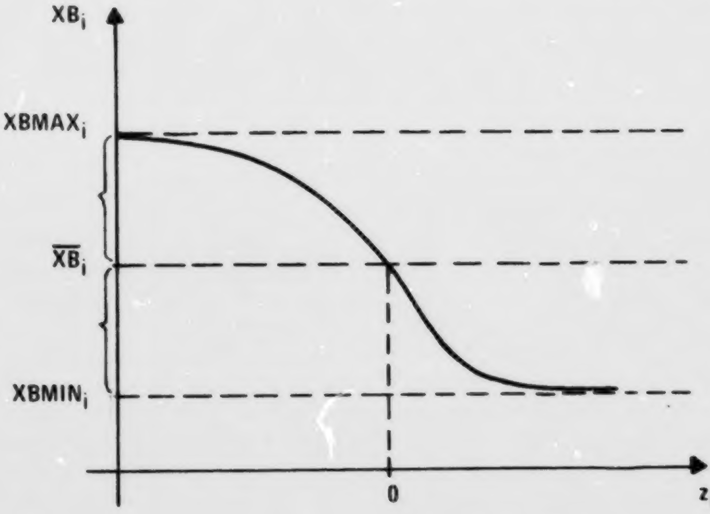
$$\alpha^* = \frac{1}{1-0.75}$$

$$\delta_1 = 1-0.30$$

$$\delta_2 = \frac{1}{0.70} - 1$$

The general behavior of the stock function is depicted in Figure 3.2.

FIGURE 3.2 ENDING STOCKS AS A FUNCTION OF CHANGES IN RELATIVE WORLD MARKET PRICES



The minimum and maximum ending stock levels together with the actual ending stocks in 1970 are reported in Table 3.3 for those commodities for which there is a stock function.

TABLE 3.3 MINIMUM AND MAXIMUM ENDING STOCKS AND REALIZED ONES IN 1970

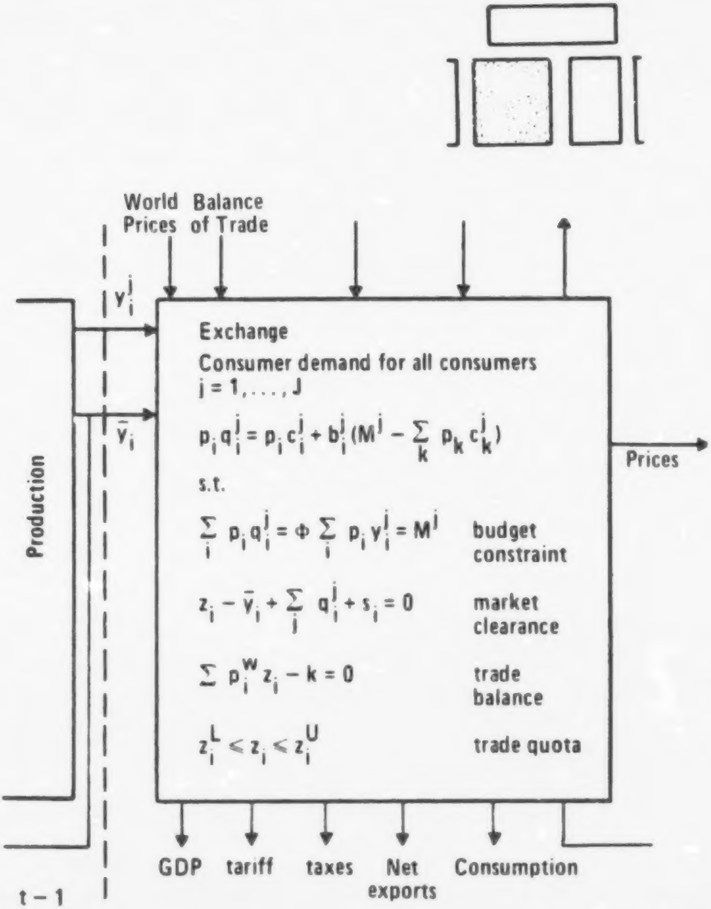
Commodity		Levels of ending stocks		
Name	Index	Minimum	Maximum	Realized in 1970
Wheat	$i = 1$	2 500	20 000	10 000
Coarse grain	3	2 000	10 000	6 000
Bovine and ovine meats	4	0	20	10
Dairy products	5	0	1 500	1 000
Protein feed	7	0	400	200
Other food	8	0	200	100
Nonfood agriculture	9	0	50	30

The demand module

Demand for goods is modeled in the BLS by using the linear expenditure system as indicated by the first equation written in the box labeled "exchange" in Figure 3.3. Below this equation, the constraints to which the demand system must adhere are indicated. Among those is the budget constraint which equates consumers' expenditures with their income. The government has the power to raise income taxes (indicated by the variable ϕ; the tax rate is $1 - \phi$) in order to maintain the financial constraint (that is, the trade deficit) for the nation. In addition to these two financial constraints, there is the market clearance equality which must be satisfied, as well at some upper and lower bounds on trade. Currently, the trade quotas are set at levels which ensure that they will never be binding. Quantity constraints on trade have been calculated as tariff equivalents and are used in this way in the model.

We tried to estimate the coefficients of the linear expenditure system but obtained unrealistic results. Therefore, we followed a more pragmatic approach. In an extensive literature search, average expenditure shares were collected. Together with information on expenditure shares at the farmgate level, these expenditure shares at the retail level were taken to determine the value of processing, marketing and distribution per unit of each commodity (hereafter called the processing margin).[6] The processing margin determines the amount of nonagricultural product needed to "transfer" a unit of a commodity from the farmgate level to the retail level. Using cross-country data, functions have been estimated which determine these processing margins as a function of per capita income.

FIGURE 3.3 INFORMATION FLOW AT THE NATIONAL LEVEL, DEMAND MODULE


World Prices
Balance of Trade
y_i^j
$\bar{y}_i$
Production
t − 1
Exchange
Consumer demand for all consumers
$j = 1, \ldots, J$
$p_i q_i^j = p_i c_i^j + b_i^j (M^j - \sum_k p_k c_k^j)$
s.t.
$\sum_i p_i q_i^j = \Phi \sum_i p_i y_i^j = M^j$
budget constraint
$z_i - \bar{y}_i + \sum_j q_i^j + s_i = 0$
market clearance
$\sum p_i^W z_i - k = 0$
trade balance
$z_i^L < z_i < z_i^U$
trade quota
Prices
GDP
tariff
taxes
Net exports
Consumption

We also estimated expenditure elasticities for each commodity by fitting nonlinear Engel curves to the time series data of the corresponding per capita expenditure. The functional forms chosen imply that expenditure elasticities are either constant or decline with increasing expenditure. These expenditure elasticities were then used to obtain the coefficients for marginal budget shares along with committed consumption for the linear expenditure system.

The production module

The importance of modeling the linkages between agriculture and the rest of the economy is stressed above. However, applied work in this area is still scattered, and the emphasis placed on some aspects of those linkages varies.

In our approach, we recognize the competition of both agriculture and nonagriculture for labor and capital by specifying behavioral equations which determine the share of each of these two inputs going to agriculture as a function of the economic situation in both sectors. Changes in the cost of the intermediate consumption items are also considered in the model. Agriculture is affected through fertilizer and other input costs. The nonagricultural sector is affected by changes in the costs of intermediate inputs, too, but, of course, to a much lesser extent. Hence, the impact of changes in relative prices on production cost is measured, although the current specification of the model does not allow an investigation of inflation effects, because the model is homogeneous of degree zero in prices. For the same reason, the impact of exchange rate changes cannot be assessed. Listing the linkages between the farm and nonfarm sectors considered in our approach, we should point out again that the interdependencies on the demand side are captured through the competition of all commodities for the consumer dollar.

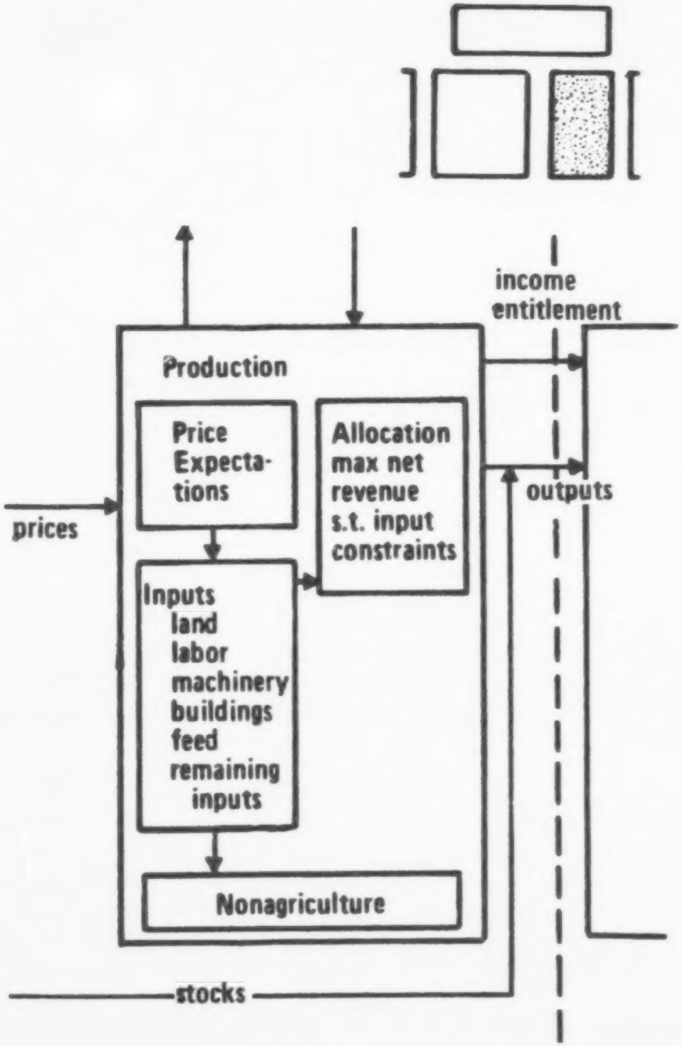
With regard to the decision making on production, we assume that the production system is separable, which permits decisions in agriculture and in nonagriculture to be partly independent. Figure 3.4 depicts the economy-wide production system as it is separated into various submodules each describing a block of decision.

The submodules are discussed in the sequence in which the information is passed through the whole production system.

Agricultural production — Agricultural production has some special characteristics which should influence the choice of the modeling approach to be used for policy analysis. There are some inputs which, for the sector as a whole, do not adjust in a short period. Land and capital are the most obvious examples. Labor comes close in developed countries where only a small portion of the labor force works in agriculture. Furthermore, production is determined by the allocation of inputs (both fixed and variable) to the various commodities. For a given technology, it is the commodity-specific input mix that determines output.

Linear programming models incorporate these characteristics and are therfore widely and succesfully used. Moreover, explicit assumptions about farmers' economic behavior is introduced, which makes these models very appealing from a theoretical point of view. Although the restrictive assumption of linear processes can be overcome by piece-wise linearization, the cost associated with such a more realistic representation of production techniques is an explosion of the model size. In addition, the number of unknowns in

FIGURE 3.4 INFORMATION FLOW AT THE NATIONAL LEVEL, PRODUCTION MODULE


income
entitlement
Production
Price Expectations
Allocation max net revenue s.t. input constraints
prices
outputs
Inputs
land
labor
machinery
buildings
feed
remaining inputs
Nonagriculture
stocks

such a model exceeds the number of observations, so an estimation of the coefficients is not possible.

Other approaches such as the dual approach and the use of direct supply systems also have their shortcomings, as can be seen from Table 3.4. While the table is certainly not exhaustive, it indicates that a combination of a programming approach with an estimation procedure is very desirable.[7]

TABLE 3.4 MODELING MULTIPLE INPUT/MULTIPLE OUTPUT SYSTEMS

	Explicit assumption of microeconomic foundation	Explicit consideration of production structure	Parameter hypothesis testability
Mathematical programming with linear production structure	yes	yes	no
Direct supply functions	no	no	yes
Dual approach	yes	yes with some limitations	yes
Mathematical programming with nonlinear production structure	yes	yes	yes

Frohberg et al. (1978) propose a nonlinear programming model with estimated parameters as an approach to model the European Economic Community for agricultural policy analysis. The structure of CAM discussed here is very similar to that proposal.

It is assumed that the numerous decisions made by farmers during a production year can be summarized into a few decision stages, thereby aggregating over time and space. In principle, two decision stages are considered. The first level deals with the input of those production factors which cannot be varied within the production year. These are assumed to be land, labor and capital. In the second level, the allocation of these predetermined and other variable inputs is determined and the amount of production is obtained simultaneously.

Expected prices — At the time farmers make their decisions, the selling price of their commodities is unknown. We therefore postulate that farmers form price expectations based on the current target price and lagged realized prices as follows:

$$ppr_{it} = 0.6\, praw_{it}^{D} + 0.3\, praw_{it-1}^{E} + 0.1\, praw_{it-2}^{E}$$

where

ppr_{it} = the expected producer price of commodity i in year t;
$praw_{it}^{D}$ = the desired raw material price of commodity i in year t; and
$praw_{it}^{E}$ = the equilibrium raw material price of commodity i in year t.

The expected price is treated as a predetermined variable in the production module.

A comparison of the commodity list reported in Tables 3.1 and 3.14 shows the difference in commodity aggregation between the exchange component and the allocation component. Hence, a mapping has to be performed to transmit the price information from the exchange commodity list to the allocation commodity list. For this mapping, two categories of aggregates are distinguished among the exchange commodities: aggregates consisting of substitutes and aggregates consisting of independent subaggregates.

The way in which the aggregate prices are split is indicated in Table 3.5. A more detailed description of the price-splitting procedure is given in the Appendix to this chapter.

Input determination of land, labor and capital — Land input adopts a simple trend function of the following kind:

$$TA_t = \alpha_{A1} + \alpha_{A2} * t$$

where

α_{A1} = parameters estimated;
TA_t = total acreage in year t; and
t = time variable (t = year minus 1960).

The parameters of this function are given in Table 3.6. It should be mentioned that no distinction is made between different soil classes and/or climatic zones. As with the other inputs, land is treated as a homogeneous factor.

The labor input of agriculture is measured by the number of people employed in agriculture. Such important characteristics as skills, total working hours and distribution of available manpower over the production year are left out. Labor is estimated according to the following migration function:

$$L_t^A = \alpha_{L1} * \left[\frac{Z_{t-1}^A}{Z_{t-1}^{NA}} \right]^{\alpha_{L2}} * L_{t-1}^A$$

α_{L1} = parameters estimated from time series;
L_t^A = agricultural labor force in year t (in 1000 persons);
Z_t^A = income per agricultural laborer in year t; and
Z_t^{NA} = income per nonagricultural laborer in year t.

TABLE 3.5 SUBAGGREGATES FOR WHICH PRICE HAS TO BE SPLIT

Name of splitting parameter	Index of aggregate i	Index of subaggregate j	Name of aggregate	Name of subaggregate	Type of splitting*
a6pr	3	1	other animals	pork, poultry, eggs	0
a6pr	3	2	other animals	fish	0
a7pr	4	1	protein feed	protein feed of crop origin	0
a7pr	4	2	protein feed	meat meal	0
a7pr	4	3	protein feed	fish meal	0
a8opr	1	1	other food	fats and oils	1
a8rpr	2	1	other food	rest of other food	1
a8frpr	5	1	rest of other food	fruit	0
a8frpr	5	2	rest of other food	nonfruit	0
a8oirp	6	1	fats and oils	vegetable oil	0
a8oirp	6	2	fats and oils	fats of ruminants	0
a8oirp	6	3	fats and oils	fat of pork	0
a8oirp	6	4	fats and oils	fish oil	0
a9pr	7	1	nonfood agriculture	fibre of crop origin	0
a9pr	7	2	nonfood agriculture	hides	0
a9pr	7	3	nonfood agriculture	wood	0

* 0 means rule for aggregates consisting of substitutes and 1 refers to the independent rule.

TABLE 3.6 PARAMETER VALUES OF THE INPUT FUNCTIONS FOR LAND, LABOR AND INVESTMENT

Type of input	First subscript of parameters in text	Parameters α_{j1}	α_{j2}	α_{j3}	α_{j4}	α_{j5}	α_{j6}	α_{j7}
Acreage	j = A	20360.00	170.00	—	—	—	—	—
Labor	j = L	1.02	0.07	0.03	1.01	0.0	0.41	0.002
Investment	j = I	0.67	0.79	0.74	−12.25	0.09	0.64	—

This function stipulates that the ratio of the current year's agricultural labor force to that of the previous year is explained by the per capita income parity between agriculture and nonagriculture, where we approximate income by gross domestic product. The parameter α_{L2}, given in Table 3.6, indicates that there is a rather small response to changes in the income parity.

To prevent drastic changes in the labor force which might be socially undesirable, bounds on migration are imposed. These bounds are set annually in the following way:

$$L_t^{A,l} = \max(0.035 * L_t^T, w2 * L_{t-1}^A)$$

with

$$w2 = 0.95 + \alpha_{L3} * e^{(-50. * \left[\frac{L_{t-1}^A}{L_t^T}\right]^2)}$$

$$L_t^{A,u} = \min(1.1 * L_{t-1}^A, 0.9 * L_t^T)$$

where

$L_t^{A,l}$ = lower bound on agricultural labor force in year t;
$L_t^{A,u}$ = upper bound on agricultural labor force in year t; and
L_t^T = total labor force in year t (in 1000 persons).

The total labor force is obtained by determining population and multiplying this by the participation rate:

$$POP_t = POP_{t-1} * GRPOP_t$$

$$L_t^T = POP_t * PART_t$$

with

$$GRPOP_t = \alpha_{L4} + \alpha_{L5} * t$$

$$PART_t = \alpha_{L6} + \alpha_{L7} * t$$

where

POP_t = population in year t (in 1000 persons);
$GRPOP_t$ = population growth rate in year t;
$PART_t$ = labor participation rate in year t; and
L_t^T = total labor force in year t (in 1000 persons).

The population growth rates are taken from data supplied by the International Labor Organization. The participation rate follows a linear time trend function according to our specification. However, reality very likely is more complex and the participation role might be determined by demographic characteristics and socio-economic conditions. But we could not estimate such a specification because of lack of information. The population is assumed to grow annually at a constant rate of 1.25%. The participation rate was 41% in 1970 with slight increases annually.

As with the labor force, we have to assume that capital is a homogeneous input factor, since lack of data do not allow us to differentiate between various capital goods. Capital stock is determined in the model in two stages. Gross investment is first decided upon and is then converted into capital stock in the following way:

$$K_t^A = K_{t-1}^A * (1 - d_t^A) + I_t^A$$

where

K_t^A = capital stock of agriculture in year t (at 1970 prices);
d_t^A = depreciation rate for agricultural capital stock in year t; and
I_t^A = gross investment in agriculture in year t (at 1970 prices).

Agricultural gross investment is described as a share of total gross investment using the functional relationship:

$$\frac{I_t^A}{I_t^T} \quad \alpha_{I1} * \left[\frac{P_{t-1}^A}{P_{t-1}^{NA}}\right]^{\alpha_{I2}} * \left[\frac{GDP_{t-1}^{A,CO}}{GDP_{t-1}^{NA,CO}}\right]^{\alpha_{I3}}$$

where

I_t^T = gross investment of the whole economy in year t (at 1970 prices);
$GDP_t^{A,CO}$ = gross domestic product of agriculture in year t (at 1970 prices);
$GDP_t^{NA,CO}$ = gross domestic product of nonagriculture in year t (at 1970 prices);
P_t^A = price index of agricultural commodities in year t; and
P_t^{NA} = price index of the nonagricultural commodity in year t.

Agricultural gross investment share is determined by the ratio of agricultural to nonagricultural price indexes and by the ratio of the outputs of the two sectors. Both explanatory variables are lagged by one year. Investment in agriculture increases relatively to that in nonagriculture if the terms of trade between the two sectors change favorably for agriculture. The ratio of the outputs of the two sectors in the previous year is taken as a proxy for the ratio of the planned outputs in the two sectors. According to this specification, the larger the ratio, the higher the gross investment in agriculture relative to that in nonagriculture. The parameters of the investment function indicate that the response to changes in these two determining ratios is relatively strong. The elasticity of agricultural investment share with regard to a change in relative prices is 0.79 and, for the ratio of planned outputs, it is 0.74 (see Table 3.6).

As with the function for labor input, the investment share equation does not take the marginal productivity of capital into account. The ratio of prices is a guide for investment going to this sector in which higher profitability might occur, but it does not equalize marginal productivity between the two sectors, even in the long run.

Total gross investment is estimated as a function of total gross domestic product at current prices, trade deficit, and the change in gross domestic product between the given year and the previous year, such that:

$$IT_t = \alpha_{I4} + \alpha_{I5} * (GDP_{t-1} + BAL_{t-1}) + \alpha_{I6} * DGDP_{t-1}$$

where

GDP_t = total gross domestic product in year t (at current prices);
BAL_t = trade deficit in year t (at current prices); and
$DGDP_t = GDP_t - GDP_{t-1}$

Determination of variable inputs — Feed and fertilizer inputs are determined on a per animal and per hectare basis, respectively. We make the simplifying assumption that other inputs for increasing crop yields (pesticides, herbicides, etc.) are applied in a fixed proportion to fertilizer input. All other variable inputs (energy, repair costs, etc.) are added up to one aggregate by using 1970 prices. The total quantity used of all these variable inputs is determined in the allocation model (described below) when the predetermined inputs are allocated and the output quantities are determined.

Minimum feed cost rations are determined for all three animal categories by considering only feed concentrates and not roughage. Information on roughage production is unfortunately not available in the FAO data set and therefore cannot be included in the model. This requires some careful interpretation of the results, especially in a country where roughage is largely produced on arable land for which ruminants and crops must be compete.

When calculating the input of feed concentrates, we assume that their supply is completely elastic. With this assumption, it is possible to determine feed mix per animal unit independently of the level of animal husbandry.

The functional form employed to determine the feed requirement coefficients is derived from a feed cost minimization model, which can be written for any animal type i and year t in the following way:

$$\min_{FD_{ikt} \epsilon I(i)} W_{it} = \sum_{k \,\epsilon\, I(i)} r_{kt} * FD_{ikt}$$

$$\text{s.t. } (y_{it} * A_{it}) = \rho_i(t) * \prod_{k \,\epsilon\, I(i)} FD_{ikt}^{\epsilon_{ikt}}$$

$$\sum_{k \,\epsilon\, I(i)} \epsilon_{ikt} = 1$$

This results in the following equation for feed intake coefficients:

$$feed_{ikt} = \frac{\epsilon_{ikt}}{r_{kt}} * \frac{y_{it}}{\rho_i(t)} * \prod_{j \,\epsilon\, I(i)} \left(\frac{r_{jt}}{\epsilon_{ijt}}\right)^{\epsilon_{ijt}}$$

where

i = commodity index, $i \in$ animals;
j,k = index of feed concentrates;
$I(i)$ = the index set of feed concentrates used for feeding animal i;
r_{kt} = price of feed concentrate k in year t;
A_{it} = number of animals of type i in year t;
y_{it} = yield per animal unit i in year t;
FD_{ikt} = total consumption of feed concentrate k by animal type i in year t;
$feed_{ikt}$ = consumption of feed concentrate k per animal unit by animal type i in year t;
W_{it} = total feed cost of animal type i in year t; and
t = time variable.

The coefficient ρ_i is time dependent. It measures technical progress in feed efficiency, reflects changes in composition of an aggregate when the various components have different feed requirements (pork, poultry and eggs) and indicates substitution of roughage by feed concentrates or vice versa (ruminants). The parameters ϵ_{ikt} measure the elasticity of output with regard to feed input. They also give the share of the cost of feed concentrate k on total feed cost, and are time dependent. The minimum feed cost ration is determined for each animal category independently.

The minimum feed cost model does not include all feed concentrates because some are of very minor importance. We select the four feed concentrates having the highest share in total feed cost. Table 3.7 indicates which of the feed concentrates are selected for the three animal types.

TABLE 3.7 FEED CONCENTRATES FOR WHICH INTAKE COEFFICIENTS ARE DETERMINED IN THE MINIMUM FEED COST MODEL

Animal		Feed concentrates
Type	Index*	(commodity index in parentheses)
Beef cattle	j = 4	wheat (1), coarse grains (7), protein feed (7), other food (8)
Dairy cattle	= 5	wheat (1), coarse grains (3), protein feed (7), other food (8)
Pork, poultry, eggs†	= 6	wheat (1), coarse grains (3), milk (5), protein feed (7)

*index follows commodity list of exchange part (see Table 3.1)
†part of other animals; the other part is fish

The estimation of the parameters of this minimum feed cost model proceeds in two steps. In the first step, the total consumption of each feed concentrate as reported in the SUA is distributed to the three animal categories dealt with in this model (see Frohberg et al., forthcoming). In the second step, we regress the feed intake coefficients on those "observed" time series.

The specification of the parameters is as follows. For the specification of the parameters ϵ_{ikt}, the side condition $\sum_{k \in I(i)} \epsilon_{ikt} = 1$ is indirectly put into the estimation procedure by first specifying a variable, say, ga_{ikt}, which is defined as:

$$ga_{ikt} = \frac{w_{ikt}}{1 + w_{ikt}}$$

where

$$w_{ikt} = \epsilon^{(afeed_{ik} + afeed_{ik+4} * t)}$$

Note that ga_{ikt} is bound between zero and unity. The time index t was equal to unity in 1961. From ga_{ikt}, we obtain ϵ_{ikt} by making the following mathematical manipulations:

$$\epsilon_{i1t} = 1. - ga_{i4t}$$

$$\epsilon_{i2t} = \prod_{j=2}^{4} g_{ijt}$$

$$\epsilon_{i3t} = \left[1. - ga_{i2t}\right] * \prod_{j=3}^{4} g_{ijt}$$

$$\epsilon_{i4t} = \left[1. - ga_{i3t}\right] * ga_{i4t}$$

The specification of the parameter $\rho_i(t)$ is determined in the following way:

$$\rho_i(t) = afeed_{i1} * e^{\gamma(t)}$$

with

$$\gamma(t) = \begin{cases} afeed_{i5} * t & \text{if } afeed_{i9} \leq -10; \\ afeed_{i5} * t & \text{if } afeed_{i9} > -10, \text{ but } t < 16; \text{ and} \\ afeed_{i5}\ 16 + afeed_{i9} * (t - 16) & \text{otherwise.} \end{cases}$$

The values of *afeed* are given in Table 3.8. The ones for $afeed_{i5}$ must be carefully interpreted for they do not necessarily indicate the strength of technical progress. The values for beef cattle and for the aggregate for pork, poultry and eggs both show positive signs, indicating an increase in the feeding efficiency, whereas there is a declining efficiency for dairy cattle. The latter phenomenon may be interpreted as a substitution of feed concentrates for roughage. More and more milk production is being achieved through use of feed concentrates.[8]

The limitation due to the omission of roughage in the ruminant diet is noted above. It also should be mentioned that physiological balances are not explicitly accounted for in this minimum feed cost model. However, they are included in the calculation of the parameters of the minimum feed cost model for the distribution of total feed consumption among the three animal types.

TABLE 3.8 PARAMETER VALUES OF THE MINIMUM FEED COST MODEL

Animal		Parameters of $afeed_{i,j}$								
Type	Index*	i = 1	2	3	4	5	6	7	8	9
Beef cattle	j = 4	0.60	5.86	2.67	1.75	0.02	–0.17	–0.02	0.002	0.01
Dairy cattle	= 6	8.20	6.53	2.70	1.76	–0.01	0.21	–0.02	0.001	0.01
Pork, poultry, eggs†	= 6	0.07	2.40	0.90	2.05	0.01	0.07	–0.03	.003	0.01

*index follows commodity list of exchange part (see Table 3.1)

†part of other animals; the other part is fish

Therefore, these balances are implicitly included in the model.

The prices of feed concentrates are derived from the expected producer prices. It is assumed that there is a ratio between these two prices which may even vary over time in those cases in which there is a change in the compositions of production and of feed consumption of the same aggregate. The following equation is applied:

$$r_{kt} = (\alpha + \beta * t) * pe_{kt}$$

where

r_{kt} = (expected) price of feed concentrate k in year t;
pe_{kt} = expected producer price of commodity k in year t; and
t = time variable (= 1 in 1971).

It should also be mentioned that the expected feed price is used only for determining feed intake coefficients. In calculating the sectoral account, the realized (equilibrium) prices are taken. The parameters α and β of the above equations are given in Table 3.9.

For all feed items not included in the minimum feed cost model, the feed intake coefficient is determined independently of prices. A linear time trend has been fitted to the "observed" coefficients over the years 1970-74. This function is used in the simulations up to 1974, and afterward the coefficient is held constant at the 1974 level, according to the following formulation:

$$feed_{ikt} = \alpha_{it} + \beta_{it} * t \qquad \text{for } t \leq 4,\ k \notin I(i)$$

The time variable t was equal to unity in 1971. The values of α and β are reported in Table 3.10. The β parameter is quite small, indicating that there was little change over those 4 years.

Those feed intake coefficients of ruminants which are determined in the minimum feed cost model are dependent on the yield level.[9] Hence, prior to determining these coefficients, yield must be determined.

Milk per cow is estimated as a funciton of the ratio of expected milk price to the index of expected feed prices and the time variable. The feed price

TABLE 3.9 RATIO OF FEED PRICE TO PRODUCER PRICE

Animal		Type of parameter	Commodity				
Type	Index*		Wheat	Coarse grain	Milk	Feed	Protein food
Cattle	j = 4,5	constant	0.90	1.0	0.25	0.95	1.49
		time	0.0	0.0	0.0	-0.04	-0.09
Pork, poultry, eggs†	j = 6	constant	0.90	1.0	0.25	0.95	1.01
		time	0.0	0.0	0.0	-0.05	-0.002

*index follows commodity list of exchange part (see Table 3.1)

†part of other animals; the other part is fish

TABLE 3.10 PARAMETER VALUES FOR DETERMINING FEED INTAKE COEFFICIENTS FOR COMMODITIES NOT COVERED IN MINIMUM FEED COST MODEL

		Feed concentrate			
Animal		Milk		Other food	
Type	Index	Constant	Time parameter	Constant	Time parameter
Beef cattle	j = 4	12.35	-0.74	—	—
Dairy cattle	= 5	61.20	0.09	—	—
Pork, poultry, eggs	= 6	—	—	0.107	0.003

index is calculated by using the previous year's feed intake coefficients as weights. For yield of beef cattle, the same specification is used. Yield of these animals does not represent the carcass weight per animal slaughtered but the carcass weight of all beef cattle slaughtered per average animal in the beef cattle herd. Yield of beef cattle has to be calculated in this way because the number of animals slaughtered is not available in the SUA data.

We use the following mathematical specification for yield:

$$y_{it} = \alpha_i * \left[prpind_{it} \right]^{\beta_i} * (t)^{\gamma_i} \qquad \text{for } i = \text{beef cattle, dairy cattle}$$

with

$$prpind_{it} = \frac{pe_{it}}{pfindex_{it}}$$

$$pfindex_{it} = pfindex_{it-1} * \frac{\sum\limits_{k} r_{kt} * feed_{ikt-1}}{\sum\limits_{k} r_{kt-1} * feed_{ikt-1}}$$

where

y_{it} = yield of animal type i in year t;
$prpind_{it}$ = ratio of expected producer price to expected feed price index of animal type i in year t;
pe_{it} = expected producer price of commodity i in year t;
$pfindex_{it}$ = index of expected feed prices of animal i in year t (= 1 in 1970);
r_{kt} = expected feed price of feed concentrate k in t;
r_{kt-1} = realized feed price of commodity k in year t;
$feed_{ikt}$ = feed intake coefficient of feed concentrate k per animal unit of animal type i in year t;
t = time variable ($t = 1$ in 1961); and
k = index of feed concentrates.

The parameters of the animal yield functions are given in Table 3.11. Yield of beef cattle has a price elasticity of 0.025 and milk yield of 0.08. These values are rather small, whereas technical progress represented by the time variable is quite large in dairy.

As fertilizer input, nitrogen is taken. Phosphate and potash are assumed to be applied to each crop in fixed proportion to nitrogen. The level of fertilizer application is a function of (expected) crop prices, fertilizer price and technology. It is assumed that farmers maximize gross revenue minus yield-increasing inputs per hectare for each crop:

$$\max_{F_{it},\ i \in crops} \quad pe^{*}_{it} * y_{it}(F_{it}) - p^{*}_{Ft} * (1 + c_i) * F_{it}$$

with

$$pe^{*}_{it} = \alpha_{8i} * pe_{it}$$

$$y_{it} = \alpha_{1i} * \left[1 - \alpha_{4i} * e^{(-\alpha_{5i} * F_{it})}\right] * g_i(t) * h_i(t)$$

$$g_i(t) = \begin{cases} 0.5\ e^{-\mu_{it}} & \text{if } \mu < 0 \\ 1.\ - 0.5\ e^{-\mu_{it}} & \text{otherwise} \end{cases}$$

$$\mu_{it} = a_{6i} * (t - a_{7i})$$

$$h_i(t) = \begin{cases} 1.0 & \text{if } t \leq 16 \\ tech_i^{(t-16)} & \text{otherwise} \end{cases}$$

$$tech_i = \begin{cases} 1.01 & \text{if } a_{10i} \leq 0. \\ 1.0 + a_{10i} & \text{otherwise} \end{cases} \qquad \text{for } i = 1,2,3$$

$$tech_i \quad \begin{cases} 1.05 & \text{if } a_{10i} \leq 0. \\ 1.0 + a_{10i} & \text{otherwise} \end{cases} \qquad \text{for } i = 4,5,6$$

where

pe^{*}_{it} = expected producer price of commodity in year t;
y_{it} = yield of commodity i in year t;
F_{it} = nitrogen applied per hectare of commodity i in year t; and
p_{it} = unit price of nitrogen in year t, used by farmers for deciding on fertilizer application.

TABLE 3.11 PARAMETER VALUES OF THE ANIMAL YIELD FUNCTIONS

Animal type	α	β	γ
Beef cattle	93.57	0.025	0.040
Dairy cattle	3 053.00	0.080	0.214

The parameters a_{g_i} represent the factor with which the marginal value product of fertilizer deviates in the "optimum" from the average shadow price of fertilizer. This deviation is assumed to be due to differences in the ratios of nitrogen to phosphate and to potash when applied to the various crops. The argument is that a ratio which is relatively small has a smaller marginal value product in the optimum than at the average. And the average shadow price should be a good approximation of the unit value of fertilizer, which is calculated in the following way:

$$p_{Ft} = p_{Nt} + \alpha_{pt} p_{pt} + \alpha_{kt} p_{kt}$$

where p_{Ft}, p_{ht} and p_{pt} stand for unit values of nitrogen, phosphate and potash, respectively. α_{pt} and α_{kt} are the average ratios of phosphate to nitrogen and of potash to nitrogen, respectively. The crop-specific unit value of fertilizer differs in the same way as that described for the shadow price.

In the phase of estimating the parameters of the yield functions, nitrogen fertilizer is not a variable input but total fertilizer application is fixed to the observed level, according to the following model:

$$\max_{F_{it}, i \in \text{crop}} \quad Z_t = \sum_{i \in \text{crop}} pe^*_{it} * y_{it} * A_{it}$$

$$\text{s.t.} \quad \sum_{i \in \text{crop}} F_{it} * A_{it} \leq TF_t$$

where

A_{it} = acreage of crop i in year t;
TF_t = total nitrogen in year t;

and all other variables are defined as above.

This model yields a shadow price of nitrogen which ideally should be equal to p_{Ft} in each year of the estimation period. But this was not the case. Various reasons might be given, for example, farmers' behavior deviates from the optimal one because of risk aversion and other factors not explicitly considered, of misspecification of yield functions, and of data problems.

For simulation purposes, this deviation must be taken into account. We take the average of the ratios of estimated shadow prices of fertilizer to the unit values of nitrogen, and this coefficient is used in the simulation runs to determine the unit value of nitrogen which is effectively used by farmers in their decision process, p_{Ft}. We have:

$$p^{*}_{Ft} = 3.67 * p_{Ft}$$

That the shadow price is always larger than the unit value of nitrogen indicates that, according to the model, farmers could apply more fertilizer to come closer to the "optimum."

The parameter values of the yield functions and that of α_{8_i} are reported in Table 3.12. The value of parameter α_{4_i} indicates the percentage of maximum yield which can be achieved without applying any fertilizer. These values are between 0.60 and 0.73. The marginal physical product is a function of $g_i(t)$ and $h_i(t)$. The former one, a logistic curve, not only increases total yield, but also shifts the marginal physical product of fertilizer upward. α_{7_i} determines the inflection point of that logistic curve. Except for wheat, this point occurs when $t = 0$, that is, in 1960. The inflection point of wheat appears in 1973, which says that technical progress in yield increases at a decreasing rate beyond 1973. The maximum yield of each crop is given by α_{1_i}. Grains have a maximum of about 12 t/ha. Notice the values of α_{1_i}, $i = 5, 6$, are difficult to interpret because of the unit of measurement of these commodities.

TABLE 3.12 PARAMETER VALUES OF THE CROP YIELD FUNCTIONS

Commodity		Parameter						
Name	Index*	α_{1i}	α_{4i}	α_{5i}	α_{6i}	α_{7i}	α_{8i}	α_{10i}
Wheat	1	12.00	0.739	0.006	30.100	13.45	1.00	0.015
Coarse grain	3	12.65	0.700	0.009	4.757	0.0	1.00	0.0
Protein feed	4	0.67	0.500	0.025	9.715	0.0	1.01	0.0
Other food	5	1.56	0.600	0.025	0.100	0.0	0.57	0.0
Nonfood agric.	6	8.74	0.600	0.030	21.788	0.0	0.25	0.0

*index follows commodity list for allocation model (see Table 3.14)

The allocation model — For the second decision-making level, namely, the allocation of the predetermined inputs (labor, land, and capital), a nonlinear programming model with a nonlinear criterion function and nonlinear inequality constraints is used:

$$\max_{K_{it}, L_{it}} \quad Z_t = \sum_i nr_{it} * y_{it} * A_{it}$$

$$\text{s.t.} \quad \sum_i K_{it} - K_t^{A} \leq 0$$

$$\sum_i L_{it} - L_t^{A} \leq 0$$

$$\sum_{i \in J} A_{it} - A_t^A \leq 0$$

$$K_{it} \geq \rho_i K_{it-1} \quad i \in J$$

with

$$A_{it} = \alpha_{it} * K_{it}^{\beta_i} * L_{it}^{\gamma_i} \qquad \text{for each } i$$

$$\beta_i + \gamma_i < 1 \qquad \text{for each } i$$

$$\alpha_{it} = a_{1i} * e^{a_{0i} * t} * (K_t^A)^{\epsilon_i - \beta_i} (L_t^A)^{1 - \epsilon_i - \gamma_i} * \left[\frac{1}{y_{it}}\right]$$

$$\epsilon_i = \beta_i + a_{8i} * (1 - \beta_i - \gamma_i)$$

$$\beta_i = a_{3i} * a_{2i}$$

$$\gamma_i = a_{3i} - \beta_i$$

$$1 > \rho_i > 0 \qquad \text{for all } i$$

where

i = commodity index (see Table 14);
t = time index;
J = index set of crops;
y_{it} = yield per hectare or per animal of commodity i in year t;
A_t^A = total acreage (harvested) in year t;
K_t^A = total capital stock in agriculture in year t;
L_t^A = total labor force in agriculture in year t;
A_{it} = acreage allocated to crop i in year t, if $i \in$ crops;
= number of animals of type i in year t, if $i \in$ animals;
K_{it} = capital employed in production of commodity i in year t;
L_{it} = labor employed in production of commodity i in year t;
nr_{it} = expected net revenue per unit of commodity i in year t, defined as expected price minus expected feed cost, if $i \in$ animals; or
= expected price minus expected cost of yield increasing inputs or commodity i in year t, if $i \in$ crops.

We postulate that the farmer maximizes expected net revenue, which is defined here as the difference between expected gross revenue and expected feed cost. The farmer is assumed to have nonstochastic behavior. We also postulate that there are decreasing returns to scale for a single product.

Technical progress is introduced in the mechanization function in two ways: it is partly embodied in the capital stock and partly measured by the time variable. A flexibility constraint is put on the allocation of capital to the various commodities. The flexibility parameter ρi takes on values of 0.7 for crops and 0.9 for animals. It says that capital cannot move freely from one commodity to another between two consecutive years. The justification for this flexibility constraint is that not all capital items can be employed in the production of many commodities. Capital goods in livestock production are assumed to be less flexible than those in crop production.[10]

Allocation of labor and capital responds to changes in prices and to the total availability of all three predetermined inputs, namely, land, labor, and capital. Although these two responses can be looked at separately, we report below the results of aggregated responses, which include in addition the response of the three (predetermined) inputs to price changes.

We wish to point out that the specification of the allocation model allows for annual decisions without explicitly considering the dynamics involved in those production processes which cover periods greater than one year (for example, beef and dairy production). However, these characteristics are taken care of implictly in the parameters of the corresponding production function and in the lag structure of the respective price expectation model.

By solving the allocatiion model, we obtain an optimal (with respect to the criterion function) use of the (predetermined) total inputs of land, capital and labor, and simultaneously an optimal net production of each commodity. Net production plus carryover in stocks is treated as supply.

There are various policy instruments which can be considered to affect agricultural production. Among those instruments which give economic incentives for production, we wish to mention producer prices and subsidies for investments production and fertilizer, as well as income transfer to influence the labor force employed in agriculture. There is also the possibility of affecting the level of inputs directly, for example, through rationing of fertilizer. In addition, quotas on production may be set.

The parameters of the mechanization functions are given in Table 3.13 (see also Table 3.14). α_{1i} is a constant factor, which functions as a scaling parameter for the mechanization equation. α_{3i} determines the sum of β_i and γ_i. The smaller this value, the larger the decreasing returns to scale for the individual crop. As can be seen, the values of α_{3i} are between 0.2 and 0.4. The α_{2i} parameters indicate the share of the α_{3i} values which are taken up by the β_i values, which are the elasticity parameters of commodity-specific capital. Except for the nonfood agriculture commodity of crop origin, the elasticity of capital is larger than that of labor. The parameters α_{8i} indicate the extent to which the isoquants are shifted parallel, if total capital or total labor changes. If $\alpha_{8i} = 0$, then only total labor shifts the isoquants of commodity *i* which is the case for coarse grains and protein feed of crop origin. A value of α_{8i} equal to unity indicates the opposite — namely a shift of the isoquant of commodity *i* by capital only. High values for α_{8i} occur for the aggregate of pork, poultry and eggs and for beef cattle and for nonfood agriculture of crop origin. α_{9i}, the time trend parameter of technical progress, is positive only for coarse grains and protein feed of crop origin. This parameter is bound to be nonzero in the estimation phase. The parameters α_{9i}

TABLE 3.13 PARAMETER VALUES OF THE MECHANIZATION FUNCTIONS

Commodity		Parameter					
Name	Index*	α_{1i}	α_{2i}	α_{3i}	α_{8i}	α_{9i}	α_{10i}
Wheat	1	512.71	0.927	0.269	0.557	0.0	0.020
Coarse grain	3	698.00	0.896	0.208	0.0	0.050	0.01
Protein feed-crop	4	130.00	0.959	0.200	0.0	0.081	0.0001
Other food	5	46.77	0.817	0.221	0.573	0.0	0.005
Nonfood agriculture crop	6	2.48	0.314	0.200	0.740	0.0	0.005
Pork, poultry, eggs	8	4.74	0.879	0.259	0.907	0.0	-10.0
Beef cattle	9	0.27	0.726	0.303	0.929	0.0	-10.0
Dairy cattle	10	0.15	0.779	0.442	0.466	0.0	-10.0
Fruits	11	14.23	0.801	0.201	0.397	0.0	-10.0

*index follows commodity list for allocation model (see Table 3.14)

and α_{10i} have to be considered together. The latter one is set by subjective judgment when the simulation results obtained are judged to be unsatisfactory by using only α_{9i}. Only when α_{10i} is set to -10.0 is the parameter not used.

Validation — For validating the model, we adopt a hierarchical procedure following the steps taken in building the model. The first validation is performed during construction of each subcomponent of a national model. At this stage, such conventional criteria as fit of estimated variables, t values, plausibility of the estimated parameters and tests for autocorrelation are used.

The next validation phase takes place when the subcomponents of a national model are linked together. Two tests are performed at this stage. We measure the tracking ability of the model by calculating Theil's inequality coefficient for those endogenous variables which had been exogenous or not generated at all at the former stage (national equilibrium prices, net trade values). However, this can be done only for the period for which the model has been estimated. In addition, we calculate summary statistics which can be compared with research work done elsewhere.

Such statistics are, for example, price elasticities of agricultural supply, which are given in Table 3.15. These elasticities are calculated by allowing all variables in the production module including those of nonagriculture to

TABLE 3.14 COMMODITY LIST FOR THE ALLOCATION MODEL OF THE BLS

Commodity		Dimension			
Number	Name	Price (in national currency, nc)	Acreage, animals, or production	Yield	Value of by-products, feed cost
1	wheat	$\frac{1000\ \text{nc}}{\text{t}}$	1000 ha	$\frac{\text{t}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
2	rice	$\frac{1000\ \text{nc}}{\text{milled rice}}$	1000 ha	$\frac{\text{t milled rice}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
3	coarse grain	$\frac{1000\ \text{nc}}{\text{t}}$	1000 ha	$\frac{\text{t}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
4	protein feed of crop origin	$\frac{1000\ \text{nc}}{\text{t protein equivalent}}$	1000 ha	$\frac{\text{t protein equivalent}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
5	other food of crop origin minus vegetable oil and fruits	$\frac{\text{nc}}{\text{U.S. \$70}}$	1000 ha	$\frac{\text{U.S. \$70 000}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
6	nonfood agriculture	$\frac{\text{nc}}{\text{U.S. \$70}}$	1000 ha	$\frac{\text{U.S. \$70 000}}{\text{ha}}$	$\frac{1000\ \text{nc}}{\text{ha}}$
7	roughage	—	—	—	—
8	other animal products minus fish	$\frac{1000\ \text{nc}}{\text{t protein equivalent}}$	1000 t protein equivalent	1	$\frac{1000\ \text{nc}}{\text{t protein equivalent}}$

9	bovine and ovine meats	$\frac{\text{1000 nc}}{\text{t carcass weight}}$	million head	$\frac{\text{t coarse wheat}}{\text{1000 head}}$	$\frac{\text{nc}}{\text{head}}$
10	dairy products	$\frac{\text{1000 nc}}{\text{t milk equivalent}}$	million head	$\frac{\text{t milk equivalent}}{\text{1000 head}}$	$\frac{\text{nc}}{\text{head}}$
11	fruit	$\frac{\text{nc}}{\text{U.S. \$70}}$	U.S $70 mil.	1	$\frac{\text{nc}}{\text{U.S \$70}}$

TABLE 3.15 OWN AND CROSS PRICE ELASTICITIES OF AGRICULTURAL SUPPLY

Commodity		Price change of commodity							
Name	Index	$i = 1$	$i = 3$	$i = 4$	$i = 5$	$i = 6$	$i = 7$	$i = 8$	$i = 9$
Wheat	$i = 1$	0.5411	0.0541	–0.0096	–0.0412	0.0560	0.0077	0.0350	0.0115
Rice	2								
Coarse grain	3	–0.0494	0.3631	–0.0454	–0.0908	–0.0285	0.0	–0.0141	–0.0040
Bovine and ovine meats	4	0.0461	0.0082	0.4776	0.0238	0.0930	0.0127	0.0506	0.0298
Dairy products	5	–0.0898	–0.0915	–0.0253	0.6484	–0.0139	0.0044	–0.0148	–0.0070
Other animal products	6	0.0140	–0.1460	0.0355	0.0011	0.7151	–0.1227	0.0398	0.0129
Protein feed	7	–0.0565	–0.0022	–0.0115	–0.0699	0.0054	0.1314	0.1248	0.0009
Other food	8	0.0122	0.0328	0.0131	–0.0412	0.0497	0.0562	0.2502	0.0056
Nonfood agriculture	9	0.0722	0.0320	0.0131	–0.0412	0.0497	0.0562	0.2502	0.0056
Nonagriculture	10	0.0777	0.0671	0.1097	–0.0119	0.0874	0.0123	0.0502	0.1967

adjust. They are numerically determined by letting the model run over a certain length of time. The price of that commodity for which own and cross price elasticities are calculated is increased by 1% over its reference value in each of the years. Because of the lag structure built into the system, the adjustment becomes stronger as more time periods elapse from the initial year, yielding in each year a new set of elasticities. The values reported in Table 3.15 are those obtained for 1984.

It should be mentioned that the allocation model does not reflect Canada's dairy policy (completely). Supply management through setting of production quota is not implemented in the system. Also, when the allocation component is estimated, the quota is not imposed, likely resulting in a supply function which lies above the actual one. It may be that the dairy response to a price change is therefore underestimated.

Table 3.15 reveals that all cross price elasticities are of relatively small magnitude. With a few exceptions, they are smaller than 0.1. It also should be noted that the cross price elasticites are not symmetric; for example, an increase in wheat price reduces coarse grains production but not vice versa. The other animal products commodity has the largest own price elasticity, which is 0.7.[11] Dairy production responds to price changes with an elasticity of 0.65 and beef with one of 0.48. Among the crops, the two grains have the largest price responses.

Estimation procedure

This section covers briefly the parameter estimation of the crop yield model and the allocation model.[12] The yield functions are specified in such a way that they depend on crop-specific application levels of nitrogen. The problem with this specification is that these nitrogen values are not observed, so we face the problem of unobservable variables. Only the total application of fertilizer is known.

As with the yield case, the mechanization functions of the allocation model also have unobservable variables as arguments. The product-specific input levels of capital and labor, K_{it} and L_{it}, are not observed. Again, only their total quantity is available as time series.

For simplicity, we adopt a new notation in defining the regression equation as:

$$Y_{it} = f_i(X_{it}, \alpha) + u_{it} \quad i = 1, \ldots, n$$

where

Y_{it} = output of product i in year t;
X_{it} = (unobserved) product-specific input vector for ith product in year t;
α = parameter vector (unknown); and
u_{it} = random error of ith product in year t.

Using the (nonlinear) least squares estimator, the estimation problem is the following:

$$(1)\quad \min_{\alpha} L = \sum_{t}\sum_{i}(Y_{it} - f_i(\alpha, X_{it}))^2$$

To generate the unobserved variables of the production functions, we solve the nonlinear programming problem for a given parameter vector, say, α^k and for all t:

$$(2)\quad \max_{X_{it}, i} Z_t = \sum_{i} P_{it} * Y_{it}$$

with $Y_{it} = f_i\,(X_{it}, \alpha^k)$

s.t. $\sum_{i} X_{it} \leq \bar{X}_t$

where

p_{it} = price of commodity i in year t;
$\bar{X}_t$ = vector of total availability of inputs in year t; and
Y_{it} = estimated output of commodity i in year t.

We assume the solution of problem (2) is unique and we call it X^k_{it}. We then can use X^k_{it} in the estimation of problem (1). Hence, for estimating the parameter vector α, we have to iterate between problems (1) and (2) till problem (1) converges.

The following steps are done in the estimation procedure:

- initiate a parameter vector, say α^1;
- solve problem (2) for all t; and
- go to problem (1) and perturb the parameter vector α to find a new one which improves the criterion function of problem 1), say, α^k and go back to the second step as long as problem (1) does not converge; otherwise stop.

The iterative procedure is necessary only because problem (2) cannot be analytically solved given the specification of the crop yield and allocation model. There are cases conceivable, however, in which the structure of problem (2) is such that X_{it} can be solved explicitly. In those cases, X_{it} can be substituted out in the regression function by the functional relation obtained from the solution of problem (2). In this case, we get:

$$Y_{it} = f_i\,(p_t, \bar{X}_t, \alpha) + u_{it}$$

where p_t is the price vector. Now Y_{it} depends only on observable variables.

The above formulation shows that obtaining the parameters of the two nonlinear programming models involves a conventional regression problem. In our case, the dependent variables are nonlinear in the parameters. For solving problem (1), a combination of Gauss and Marquardt algorithm is used. Hypothesis testing with the t statistics is possible only if the nonlinearity is not severe. But there are other statistics which are less dependant on linearity, such as the likelihood ratio test or the distance ratio test.

There is an additional aspect which needs some explanation. Experience has shown that it is extremely difficult to obtain a final parameter vector α which leads to a solution of problem (2) with satisfactory input allocation. We therefore adapt a Bayesian approach and put some prior information into the estimation problem which now becomes:

$$(1') \quad \min_{\alpha} L = \sum_{t} \left[\sum_{i} (Y_{it} - \hat{Y}_{it})^2 + \sum_{k} w_k \sum (\bar{X}_{ikt} - X_{ikt})^2 \right]$$

where

w_k = weight for the kth input;
X_{ikt} = allocation of kth input to ith product in year t;
$\bar{X}_{ikt}$ = prior information of allocation of kth input to ith product in year t;

and all other variables are defined as above. The weights w_k are subjectively determined.

Appendix

There is only one aggregate whose price is split according to the independent-subaggregate rule. This is the "other food" price, which is split into a price of the oil component, *pprois*, and a component "rest of other food." The oil component is split into a price split further with *a8oirp* (see Table 3.5), whereas the "rest of other food" is futher subdivided as *a8frpr*. The formula applied for the oil component and the "rest of other food" is:

$$ppr_{ijt} = w_{ijt} * \frac{ppr_{it} * \bar{Q}_{it}}{Q_{ijt}} \qquad \text{for } j = 1,2$$

where

$$w_{ijt} = w^*_{ijt} / (w^*_{i1t} + W^*_{i2t})$$

$$w^*_{ijt} = \frac{e^{(\alpha_{ij} + \beta_{ij} * t)}}{1 + e^{(\alpha_{ij} + \beta_{ij} * t)}}$$

with

ppr_{ijt} = the price of subaggregate j of aggregate i in year t;
w_{ijt} = the splitting parameter;
t = the time index, from 1976 onward t remains constant at its 1976 level;
i = index of aggregate, here other food ($i = 1$); and
j = index of subaggregate, here either oil component ($j = 1$) or "rest of other food" component ($j = 2$).

The values of the parameters α_{ij} and β_{ij} are presented in Table 3.A1.

Notice that both these prices are split further by using the rule for substitutes.

TABLE 3.A1 PARAMETER VALUES OF THE FUNCTIONS DETERMINING PRICE SPLITTING COEFFICIENTS

Splitting of coefficient		Type of splitting function*	Parameter	
Name	Index		α	β
a8opr	$i=1$ $j=1$	1	-0.617	-0.025
a8opr	$i=2$ $j=1$	1	0.617	0.025
a6pr	$j=3$ $i=1$	0	1.016	-0.005
a6pr	$=2$	0	0.953	0.015
	$i=4$ $j=1$	0	0.957	-0.026
	$=2$	0	1.285	-0.166
	$=3$	0	1.466	-0.130
a8frpr	$i=5$ $j=1$	0	0.934	0.010
	$=2$	0	1.254	-0.039
a8ojpr	$i=6$ $j=1$	0	1.048	-0.025
	$=2$	0	0.440	-0.049
	$=3$	0	0.989	-0.066
	$=4$	0	1.908	-0.016
a9pr	$i=7$ $j=1$	0	0.929	-0.016
	$=2$	0	1.279	-0.056
	$=3$	0	0.0	0.0

*0 means rule for aggregates consisting of substitutes and 1 refers to the independent rule

Price splitting of an aggregate consisting of subaggregates which are close substitutes is done under the assumption that the ratios of expected prices of the disaggregates to the aggregate price remain constant. However, the variations observed in the period for which we have information are maintained in the simulation runs. The following formula is applied:

$$pe_{lt} = \delta_{ijt} * \frac{ppr_{ijt} * Q_{it}}{\sum\limits_{j \in J} \delta_{ijt} * Q_{ijt}} \qquad \text{for all } l \in J$$

where

pe_{lt} = expected producer price of commodity l obtained from commodity aggregate i as subaggregate j in year t;
ppr_{it} = expected producer price of aggregate i in t;
Q_{ijt} = quantity of subaggregate i belonging to aggregate i in year t;
l = index of relating to double index i,j; l refers to the commodity list of the allocation model; and
J = index set of aggregate i.

The price-splitting parameter, w_{ijt}, is obtained using the linear trend function:

$$w_{ijt} = \alpha_{ij} + \beta_{ij} * t \qquad \text{for } t \leq 4 \text{ and } t = 1 \text{ in } 1971$$

The values determining the price-splitting parameter are listed in Table 3.A1.

Notes

1. Although not all countries are included in the BLS with an individual model, those which are not are represented by a simplistic regional model, of which there are 15. The individual models and the simplistic regional models together cover the whole world.
2. Balance is achieved also at the international level; otherwise, there would be a sink taking up all the slacks.
3. This was done by Professor J. Graham, from the University of British Columbia.
4. In the case of Canada, we are especially fortunate to have received invaluable suggestions from Professor J. Graham and from Dr. B. Huff and Dr. G. Robertson, both from Agriculture Canada.
5. The specifications given here differ from those reported by Robertson and Huff (1983, p. 67).
6. Expenditure share at the farmgate of commodity i is defined as consumption of that commodity times its farmgate price divided by total GDP.
7. Colman (1983) and Just et al. (1983) provide a discussion of the characteristics of the various approaches.
8. The increase in feed efficiency for the aggregate of pork, poultry and eggs does not necessarily represent technical progress. It might just be the result of a change in commodity mix. The share of poultry and/or eggs in the aggregate might increase and that of pork might decrease. This in itself would lead to reduced feed intake because of the higher efficiency of poultry and layers.
9. For the aggregate of pork, poultry and eggs, yield is not determined for the number of animals, A_{it} but is the actual total production measured in protein equivalents (see Table 3.14).
10. The constraints are rarely binding.
11. This is an aggregate elasticity of the aggregate of pork, poultry and eggs and also of fish. Since fish production is not responsive to price, the elasticity of the aggregate of pork, poultry and eggs is even larger.
12. A more detailed discussion can be found in Pflug (1984) and in Frohberg et al. (1978).

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4

The Input-Output Structure of Agriculture in Canada

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*Aftab A. Syed**

Introduction

Input-output tables provide a detailed accounting of the amounts of goods and services that individual industries buy from and sell to each other. They therefore constitute a useful medium for analyzing the interdependent nature of an economy. The framework of the Canadian input-output (I-O) tables, at a high level of disaggregation, distinguishes 191 industries, 602 commodities, and 136 categories of final demand. The inputs and outputs of industries, are classified by commodity and are presented in separate tables. Commodities are clearly distinguished from industries, and the number of commodities identified exceeds the number of industries. This rectangular framework has the advantage that it admits as much detail as the basic census sources provide and that the interpretation of each entry in the table is rather straightforward since observed transactions are not combined with fictitious transfers.

Input-output tables for Canada are available for the years 1961 to 1980. The year 1979 was selected as the reference year to analyze the I-O structure of agriculture in Canada. This is accomplished in the second section of this paper. Input-output models are useful in measuring the impact of exogenously specified changes in the bill of final demand on the production levels of the economic system. Both national and interprovincial output determination models (of the "open" variety) were used to perform simulations. Results of these simulations are reported and discussed in the third section of this paper. The fourth section summarizes the discussion and offers suggestions for further research.

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*Aftab A. Syed is a Senior Analyst, Statistics Canada. The author owes a great deal for encouragement and support in writing this paper to his colleagues Y. Siddiqi, Mike Palme, Nugent Miller, Ronald Rioux and Michel Bédard. Competent computational assistance diligently provided by Terry Delaney is also acknowledged. Opinions expressed in the paper are those of the author alone. None of the above individuals, nor Statistics Canada, are to be held responsible for the views expressed herein. Comments provided by two anonymous referees were extremely useful in clarifying certain points raised in the paper as well as in improving the general manner of presentation. The remaining errors or shortcomings are, however, the author's responsibility.

The agriculture sector in an input-output framework

The agriculture sector produced goods and services worth $14.4 billion in 1979. Income arising in this sector (gross domestic product at factor cost) amounted to $8.1 billion in nominal terms and accounted for 3.3% of the total economy ($245.5 billion). This small contribution to the total GDP (at factor cost) does not, however, reveal the interdependency of this sector's activities with the rest of the economy. Many commodities produced by the agriculture sector are utilized by various processing sectors as intermediate inputs before transformation into goods for final consumption.

A description of the disposition of the agriculture sector's output between intermediate uses by processing sectors and final consumers is shown in Table 4.1. An examination of the second column of this table reveals that agri-complex industries[1] utilize a substantial proportion of the output of agriculture sectors. Of the livestock outputs, for example, slaughtering and meat processors use 90% of cattle and calves, 69% of sheep and lamb, 87% of hogs, 97% of poultry, and about 72% of other live animals. Of the field crops, although 78% of the output of unmilled wheat is slated for export, 22% enters the production process as intermediate inputs, mainly to the flour and breakfast cereals industry and to feed manufacturers. Almost 99% of whole fluid milk ends up being processed by dairy factories.

Although Canada imports roughly $272 million worth of fresh fruits (excluding tropical fruits), about 54% of the domestic output is slated for processing by fruit and vegetable industries. Similarly, 58% of the output of fresh vegetables is processed.

It is apparent that production activity in the agriculture sector cannot be examined in isolation. The purpose of this paper is to analyze its interrelatedness with other sectors of the economy. An agri-complex comprised of those industries that are mainly engaged in processing the output of agriculture is identified (see note 1). The rest of the economy is aggregated into one large sector, called the industry complex. Interaction and interrelatedness between agriculture, the agri-complex and the industry complex is the main focus of the discussion that follows.

TABLE 4.1 SUPPLY AND DISPOSITION OF AGRICULTURE SECTOR'S OUTPUTS, 1979

Commodity	Outputs 1	Intermediate use: By agri-complex** 2	Intermediate use: By agri-culture 3	Final use: CE 4	Final use: Exports 5	Final use: Imports 6	Final use: Other final demand 7	Total use [2+4+5+6+7]
	(millions of dollars)							
001 Cattle and calves	3,557.0	3,197.9	512.5	133.6	199.2	−21.5	47.9	3,557.0
002 Sheep and lambs	24.0	16.4	–	3.6	...	−1.6	4.2	24.0
003 Hogs	1,432.3	1,244.9	16.2	40.3	18.9	−...	128.5	1,432.3
004 Poultry	646.2	628.7	8.4	22.1	11.1	−23.7	8.1	646.2
005 Other live animals	58.1	41.8	–	30.6	17.8	−32.1	...	58.2
007 Wheat, unmilled	2,269.3	521.0	8.4	–	1,775.3	−...	−27.1	2,269.1
008 Grain, unmilled, excl. wheat	807.2	581.9	88.5	–	517.0	−124.1	−167.4	807.5*
009 Milk, whole, fluid, unprocessed	1,883.2	1,863.0	–	21.4	–	−...	−1.3	1,883.2
010 Eggs in the shell	354.2	76.3	–	295.3	9.6	−28.0	1.0	354.2
011 Honey and bee wax	49.8	19.1	–	45.7	10.7	−...	...	75.4*
012 Nuts, edible, not shelled	2.3	7.7	–	6.0	...	−11.8	...	2.3
013 Fruits, fresh, excl. tropical	252.2	135.3	–	349.0	37.7	−271.7	1.7	252.2
014 Vegetables, fresh	672.9	390.8	30.4	528.3	41.6	−293.0	6.3	674.0*
015 Hay, forage, and straw	10.3	21.5	4.0	–	4.5	−16.2	...	10.3

(continued)

TABLE 4.1 SUPPLY AND DISPOSITION OF AGRICULTURE SECTOR'S OUTPUTS, 1979 (Concluded)

Commodity	Outputs 1	Intermediate use		Final use				Total use [2+4+5+6+7]
		By agri-complex** 2	By agri-culture 3	CE 4	Exports 5	Imports 6	Other final demand 7	
				(millions of dollars)				
016 Seeds excl. oil and seed grades	75.2	71.9	67.9	15.9	30.7	−44.7	1.3	75.2
017 Nursery stock, related material	248.9	33.0	.3	263.5	11.2	−68.6	9.7	248.9
018 Oil seeds, nuts and kernels	1,290.4	535.1	31.0	3.3	769.0	−176.4	160.8	1,291.8*
019 Hops incl. lupulin	2.3	5.4	–	–	1.9	−5.1	...	2.3
020 Tobacco, raw	201.3	275.8	–	–	16.5	–	−91.0	201.3
021 Mink skins, ranch, undressed	45.4	56.9	–	–	40.6	−52.8	...	45.4
022 Wool in grease	1.8	2.4	–	–	...	−1.7	...	1.8
023 Services agri; Forestry	198.2	151.0	–	79.5	–	–	8.6	239.1*
024 Logs and bolts	14.8	2,408.1	1.1	–	55.8	−76.7	7.4	2,394.6*
025 Poles, pits, props, fence posts etc.	4.2	33.9	–	–	8.5	−10.3	2.4	34.5*
026 Pulp wood	15.6	1,133.8	–	–	13.6	−21.0	−2.0	1,124.5*
027 Other crude wood materials	67.9	16.4	–	98.5	8.2	−6.2	...	116.9*

052	Meat excl. poultry	127.8	2,098.3	–	2,757.9	356.8	−305.6	−40.9	4,866.5*
062	Hides and skins, raw, other	5.6	124.1	–	–	128.2	−67.7	−4.5	180.0*
063	Crude animal products, other	13.7	21.5	–	–	15.1	−4.9	...	31.4*
065	Poultry, fresh, chilled and frozen	27.8	252.4	–	683.5	2.1	−23.6	17.2	931.6*
107	Maple sugar and syrup	32.5	33.0	–	31.3	16.2	−5.2	5.1	80.5*
559	Other rent	12.5							
Total		14,404.9	15,999.4	768.9	5,409.7	4,119.3	−1,695.0	78.6	23,912.1

* Discrepancy between "outputs" and "total use" is because the commodity in question is also produced by other agriculture-related industry

**See note 1 in the text for the definition of "agri-complex" industries

The relationship among agriculture, agri-complex and industry complex

The Canadian I-O accounts, as pointed out earlier, are set out in a rectangular format. An industry may produce more than one commodity. Similarly, in order to produce a given output, industries typically use more than one commodity (raw materials, fuel and electricity, labor and so on) as inputs. This implies that the number of commodities exceeds the number of industries. Input-output models are developed from the information contained in Figure 4.A1 (shown in the Appendix to this paper). In their simplest expression, they take the form of tables which summarize the impact of deliveries to final use on levels of productive activities.

The impact tables are based on two assumptions. The first is that each commodity is produced by industries in fixed proportions. These proportions are referred to as the market shares of industries in the production of each commodity (see the D matrix discussed below). The second assumption is that, in order to produce each dollar of output, an industry requires certain fixed values of commodity imports. This assumption implies that the inputs of any industry are proportional to the output of the industry irrespective of the level of that output and its commodity composition. The B matrix (also discussed below) represents these input coefficients.[2]

Let us examine the market shares matrix D, which is presented in Table 4.2. It shows that the agriculture sector, obviously, produces all the livestock, grains, whole fluid milk, eggs in the shell, fresh fruits (excluding tropical), fresh vegetables and so on. In other words, this sector is a producer of primary agricultural commodities, and as such its importance for the economy can hardly be overstated. Analytically, however, it is more important to examine the role of agricultural sector vis-à-vis those sectors that use the output of this sector for further processing. We learn about this interrelationship by looking at the columns of agri-complex industries—the processors of agricultural commodities. Slaughtering and meat processors, for example, produce all the cured meat, animal oils and fats and lard, and feeds of animal origins. Additionally, they produce 86% of fresh, chilled or frozen horse meat, 88% of the canned meat, 91% of primary tankage, 92% of cooked meat and all the cured meat and animal fats and lard. Similarly, all the canned poultry and 94% of chilled and frozen poultry is produced by poultry processors. Other agri-complex industries—dairy factories, fruit and vegetable processors, feed manufacturers and so on—are also the main users of the outputs of primary agricultural commodities. This can readily be ascertained from the table in question. Beyond the agri-complex industries, there are very few agricultural commodities that are processed by the industry complex. It suggests, then, that the chain of processing agricultural commodities is restricted only to a maximum of 18 industries.

Another matrix—input coefficients matrix B—is presented in Table 4.3. It describes the cost structure of industries under study. For ease of presentation, some 602 commodity inputs have been aggregated into 12 major groups such as materials, containers, energy services and so on.

This table shows that expenditure on material inputs by the agri-complex industries is by far the biggest cost item. Of each dollar spent, nearly 82¢ goes toward the purchase of materials by slaughtering and meat processors followed by vegetable oil mills (about 80¢), feed manufacturers (72¢), poultry processors and dairy factories (71¢). Biscuit manufacturers and bakeries spend almost an equal amount (40¢) on materials. Distilleries spend 42¢ out of every dollar on materials.

Another important cost item is the labor cost (wages and salaries and supplementary labor income). Bakeries spend about 36¢ out of every dollar on labor followed by biscuit manufacturers at 29¢. Soft drink manufacturers spend 26¢ of every dollar on labor. Vegetable oil mills spend by far the least amount on labor at 4¢ out of every dollar.

Other operating surplus—listed as surplus in Table 4.3—is a residual item. It is the difference between the total costs and all clearly identified cost items of an industry. It encompasses income earned from sources such as interest and other investment income, capital consumption allowances, and inventory and miscellaneous valuation adjustments. As these incomes are not directly related to the sectoral production, the surplus, as recorded in the table, can only be treated as a proxy for profits. Looking at the surplus column in Table 4.3 it is apparent that distilleries show by far the largest surplus at about 23¢ on a dollar of sales. Next in line are confectionery manufacturers with a surplus of 19¢, followed by miscellaneous food industries (15¢). Poultry processors and slaughtering and meat processors, on the other hand, show a surplus of roughly 5¢ and 4¢ on a dollar of sales, respectively. The agriculture sector, as a separate entity, earns 25¢ on a dollar of sales, whereas the industry complex posts a surplus of about 18¢ on a dollar of sales.

On the basis of market share and input matrices, the commodity production among industries and intermediate inputs (materials, containers, primary input and so on) required to produce these commodities can be explained. The latter are, however, direct requirements corresponding to a given level of production of commodities. To measure changes in production levels of industries arising out of changes in the bill of final demand, the direct requirements alone are not sufficient. A unit increment of final demand

TABLE 4.2 MARKET SHARE COEFFICIENTS MATRIX (D), AGRI-COMPLEX, 1979

Commodity	Agriculture	Slaughtering meat processing	Poultry processors	Dairy factories	Fruit and vegetable processing	Feed manufactures	Flour and breakfast cereals	Bakeries	Vegetable oil mills	Industry complex
Cattle and calves	1.00	–	–	–	–	–	–	–	–	–
Sheep and lambs	1.00	–	–	–	–	–	–	–	–	–
Hogs	1.00	–	–	–	–	–	–	–	–	–
Poultry	1.00	–	–	–	–	–	–	–	–	–
Other live animals	1.00	–	–	–	–	–	–	–	–	–
Wheat, unmilled	1.00	–	–	–	–	–	–	–	–	–
Grain, unmilled excl. wheat	1.00	–	–	–	–	–	–	–	–	–
Milk, whole, fluid, unprocessed	1.00	–	–	–	–	–	–	–	–	–
Eggs in the shell	1.00	–	–	–	–	–	–	–	–	–
Honey and bee wax	0.66	–	–	–	–	–	–	–	–	–
Nuts, edible, not shelled	1.00	–	–	–	–	–	–	–	–	–
Fruits, fresh, excl. tropical	1.00	–	–	–	–	–	–	–	–	–
Vegetables, fresh	1.00	–	–	–	–	–	–	–	–	–
Hay, forage and straw	1.00	–	–	–	–	–	–	–	–	–

Seeds, excl. oil and seed grades	1.00	–	–	–	–	–	–	–	–	–
Nursery stocks, related material	1.00	–	–	–	–	–	–	–	–	–
Oil seeds, nuts and kernels	1.00	–	–	–	–	–	–	–	–	–
Crude animal products, other	0.44	0.53	–	–	–	–	–	–	–	–
Custom work, meat and food	–	0.32	–	–	–	–	–	–	–	–
Poultry, fresh, chilled and frozen	0.03	0.03	0.94	–	–	–	–	–	–	–
Poultry, canned	–	–	1.00	–	–	–	–	–	–	–
Milk, whole, fluid, processed	–	–	–	1.00	–	–	–	–	–	–
Cream, fresh	–	–	–	1.00	–	–	–	–	–	–
Butter	–	–	–	1.00	–	–	–	–	–	–
Cheese, incl. processed cheese	–	–	–	0.99	–	–	–	–	–	–
Milk, evaporated	–	–	–	1.00	–	–	–	–	–	–
Ice cream	–	–	–	1.00	–	–	–	–	–	–
Other dairy products	–	–	–	0.97	–	–	–	–	–	–
Fruits, berries, processed, not canned	–	–	–	0.03	0.92	–	–	–	–	–
Fruits, preparation, canned	–	–	–	–	0.81	–	–	–	–	–

(continued)

TABLE 4.2 MARKET SHARE COEFFICIENTS MATRIX (D), AGRI-COMPLEX, 1979 (Continued)

Commodity	Agriculture	Slaughtering meat processing	Poultry processors	Dairy factories	Fruit and vegetable processing	Feed manufactures	Flour and breakfast cereals	Bakeries	Vegetable oil mills	Industry complex
Vegetables, processed, not canned	–	–	–	–	0.98	–	–	–	–	–
Vegetables, preparation, canned	–	–	–	–	1.00	–	–	–	–	–
Soups, canned	–	–	–	–	1.00	–	–	–	–	–
Pickles, relishes, other sauces	–	–	–	–	0.87	–	–	–	–	–
Vinegar	–	–	–	–	1.00	–	–	–	–	–
Other food preparation	–	0.03	–	0.04	0.36	–	–	–	–	0.39
Primary or concentrated feed	–	–	–	–	–	0.90	–	–	–	–
Feed for commercial livestock	–	–	–	–	–	0.99	–	–	–	–
Feeds of grain origin, other	–	–	–	–	–	0.28	0.53	–	–	–
Feeds of vegetable origin, other	–	–	–	–	–	1.00	–	–	–	–

Pet feeds	–	–	–	–	–	0.96	–	–	–	–
Wheat flour	–	–	–	–	–	–	1.00	–	–	–
Breakfast cereal products	–	–	–	–	–	–	0.82	–	–	–
Bread and rolls	–	–	–	–	–	–	–	1.00	–	–
Other bakery products	–	–	–	–	–	–	–	0.68	–	–
Oil seeds, meal and cake	–	–	–	–	–	–	–	–	1.00	–
Vegetable oils, fats, excl. refined	–	–	–	–	–	–	–	–	1.00	–
Fats and chemical Mixtures	–	–	–	–	–	–	–	–	1.00	–
Agricultural chemicals	–	–	–	–	–	–	–	–	0.83	–
Rental of office equipment	–	–	–	–	–	–	–	–	0.86	–
Rental of auto and trucks	–	–	–	–	–	–	–	–	0.84	–
Machinery equipment rental	–	–	–	–	–	–	–	–	0.81	–
Hops incl. lupulin	1.00	–	–	–	–	–	–	–	–	–
Tobacco, raw	1.00	–	–	–	–	–	–	–	–	–
Mink skins, ranch, undressed	1.00	–	–	–	–	–	–	–	–	–
Wool in grease	1.00	–	–	–	–	–	–	–	–	–

(continued)

TABLE 4.2 MARKET SHARE COEFFICIENTS MATRIX (D), AGRI-COMPLEX, 1979 (Concluded)

Commodity	Agri-culture	Slaugh-tering meat proces-sing	Poultry proces-sors	Dairy fac-tories	Fruit and vege-table proces-sing	Feed manufac-tures	Flour and break-fast cereals	Bake-ries	Vege-table oil mills	Industry complex
Logs and bolts	0.01	–	–	–	–	–	–	–	–	0.99
Poles, pits, props, fence posts etc.	0.12	–	–	–	–	–	–	–	–	0.88
Pulp wood	0.01	–	–	–	–	–	–	–	–	0.98
Other crude wood materials	0.59	–	–	–	–	–	–	–	–	0.30
Meat excl. poultry	0.03	–	–	–	–	–	–	–	–	–
Horse meat, fresh, chilled and frozen	–	–	–	–	–	–	–	–	–	–
Meat, cured										
Meat, preparation, cooked, not canned	–	–	–	–	–	–	–	–	–	–
Meat, preparation, canned	–	–	–	–	–	–	–	–	–	–
Animal oils and fats and lard	–	–	–	–	–	–	–	–	–	–

Sausage casings, natural and synthetic	–	–	–	–	–	–	–	–	–	–
Primary tankage	–	–	–	–	–	–	–	–	–	–
Feeds of animal origins, other	–	–	–	–	–	–	–	–	–	–
Hides and skins, raw, other	0.03	–	–	–	–	–	–	–	–	–

TABLE 4.3 INPUT COEFFICIENT, MATRIX B, 1979

Commodity	Materials	Containers	Transp.	Storage	Energy	Margins	Services	GGS	Taxes	Primary inputs	NIUB	Surplus	Total
Agriculture	0.345	0.001	0.002	0.002	0.016	0.041	0.041	0.053	0.041	0.066	0.252	0.244	1.000
Slaughtering and meat processors	0.816	0.008	0.001	0.001	0.003	0.022	0.008	0.001	0.003	0.093	0.001	0.039	1.000
Poultry processors	0.706	0.028	0.001	0.004	0.006	0.038	0.008	0.000	0.003	0.152	0.000	0.051	1.000
Dairy factories	0.715	0.029	0.002	0.000	0.006	0.044	0.015	0.029	0.006	0.120	0.000	0.088	1.000
Fruit and vegetable processing	0.577	0.029	0.002	0.003	0.010	0.056	0.025	0.000	0.007	0.168	0.000	0.120	1.000
Feed manufacturers	0.719	0.011	0.002	0.020	0.007	0.071	0.018	0.011	0.006	0.079	0.001	0.074	1.000
Flour and breakfast cereals	0.616	0.034	0.003	0.040	0.008	0.063	0.016	0.005	0.003	0.117	0.000	0.102	1.000
Biscuit manufacturers	0.405	0.081	0.003	0.000	0.011	0.039	0.033	0.001	0.010	0.292	0.000	0.124	1.000
Bakeries	0.397	0.038	0.002	0.000	0.011	0.050	0.029	0.000	0.009	0.357	0.021	0.083	1.000
Confectionery mfrs.	0.488	0.045	0.002	0.002	0.007	0.036	0.031	0.000	0.007	0.190	0.000	0.188	1.000
Sugar refineries	0.678	0.016	0.005	0.000	0.016	0.088	0.013	0.000	0.009	0.107	0.000	0.064	1.000
Vegetable oil mills	0.798	0.004	0.003	0.025	0.011	0.035	0.004	0.000	0.003	0.039	0.000	0.074	1.000
Misc. food industries	0.582	0.022	0.002	0.004	0.010	0.048	0.023	0.000	0.005	0.143	0.000	0.154	1.000
Soft drink mfrs.	0.530	0.014	0.001	0.000	0.008	0.017	0.022	0.001	0.012	0.263	0.003	0.126	1.000
Distilleries	0.417	0.033	0.005	0.005	0.020	0.030	0.035	0.004	0.039	0.182	0.000	0.226	1.000
Mfrs. of pharmaceuticals and medicines	0.473	0.013	0.005	0.000	0.006	0.015	0.075	0.002	0.009	0.271	0.001	0.130	1.000
Wholesale trade	0.165	0.007	0.015	0.009	0.011	0.018	0.087	0.002	0.021	0.457	0.029	0.178	1.000
Retail trade	0.133	0.012	0.008	0.002	0.029	0.004	0.095	0.018	0.027	0.475	0.072	0.138	1.000
Laboratory supplies	0.815	0.000	0.000	0.000	0.000	0.112	0.000	0.000	0.072	0.000	0.000	0.000	1.000
Industry complex	0.338	0.002	0.041	0.000	0.044	0.034	0.077	0.009	0.041	0.228	0.022	0.178	1.000

expenditure, in addition to an initial (direct) increase in expenditures by industries, generates successive rounds of expenditures by industries to fulfill the additional requirement placed on them, yielding indirect effects. Both these effects must be traced throughout the productive system to account for the total effects of the initial change in the autonomous expenditures. This can be conveniently studied by analyzing the impact matrix discussed in the next subsection.

Impact analysis

The relationship between the initial expenditure and the total effects triggered by the expenditure is known as the impact of the sector on the economy as whole or the multiplier effect. As such, the study of multipliers has come be called impact analysis. The modern concept of income multipliers is usually associated with Keynes.[3] Since Keynes dealt in broad aggregates, his income and employment multipliers were also highly aggregated. Although these aggregative multipliers are useful analytical tools, they do not show the details of how multipliers effects are worked out throughout the economy.

Analysts are more often interested in sectoral details than in the overall impact. Measuring the disaggregated effects of the initial stimulus to the agriculture sector of the economy will undoubtedly show an immediate (direct) impact on this sector. But how will the effects of stepped-up activity in agriculture spread throughout the economy? Given the interdependence of economic activities, it is apparent that the total impact will not be limited to those industries directly affected. Sectoral multipliers, derived from an input-output model, provide this useful information.

The impact matrix[4] for the industries under study is presented in Table 4.A1 of the Appendix. This table shows both the direct and indirect requirements of domestically produced goods and services per dollar of delivery to final demand. The direct inputs are those used by the industry under consideration, whereas indirect input requirements refer to the inputs purchased by all other industries in which production is required to enable them to supply inputs to the first industry. Thus, an impact matrix traces the total impact of an initial stimulus throughout the economy.

Reading across the columns of Table 4.A1 shows that a dollar increase in final demand in agriculture leads to an increase of $1.09 in agriculture output, an increase of 11¢ in the output of feed manufacturers, and an increase of 44¢ in the output of the industry complex. Similarly, a dollar expenditure in slaughtering and meat processing industries generates an increase of $1.22 in its own output, and an additional 73¢ worth of output is created in agriculture. The industry complex supplies 45¢ worth of its output to the slaughtering and meat processors. Similar interpretations apply to the figures reported for other sectors in this table.

The impact matrix, as explained earlier, reflects the multiplier effects of an exogenously specified expenditure. Column sums of this matrix thus are output multipliers[5] relating to a unit increase in final demand. In a fashion analogous to the solution for output multipliers, income and employment multipliers can also be calculated.[6]

Let us examine the calculated output, income and employment multipliers for agriculture, the agri-complex and the industry complex. These are shown in Table 4.4.

A glance at the first column of this table shows that slaughtering and meat processors have the highest output multipliers at 2.60, meaning that a dollar increase in its final demand results in an output increase of $2.60. This is followed by the flour and breakfast cereals industry with 2.47, dairy factories with 2.46, and vegetable oil mills with 2.19 for their output multiplier value. On the other hand, if there is a unit increase in the final demand for agriculture and also a unit increase in the final demand for the industry complex, these increases yield output multipliers of 1.74 and 1.75, respectively. Although the multipliers values are invariably greater than unity (as expected), it is important to note that these values are consistently higher for the agri-complex industries. This suggests that, if the Canadian economy is subdivided in three distinct subgroups—agriculture, agri-complex (as illustrated), and industry complex (all industries excluding agriculture and the agri-complex)—then a unit increase in final demand leads to higher increases in the output of the agri-complex than in agriculture and the industry complex considered alone.

Looking at the middle column shows that an increase of 1.55 in income arising in agriculture corresponds with an output increase of 1.74, whereas the industry complex reports an increase of 1.78 in income arising corresponding to an output increase of 1.78. However, among the agri-complex industries, the largest increase in income arising (6.28) is shown by slaughtering and meat processors.[7] Similarly, an output increase of 2.47 in the flour and breakfast cereals industry gives rise to an income increase of 3.89.

Similarly, a glance at the third column of the table shows the employment multipliers that correspond to increases in output and income in the industries in question. In agriculture, for example, direct creation of one new job results in a total of 1.36 jobs throughout the industry.[8] The industry complex shows an employment multiplier of 1.84, which is higher than its output and income multiplier. It means a unit increase in final demand has a relatively

TABLE 4.4 OUTPUT, INCOME AND EMPLOYMENT MULTIPLIERS, 1979

Industry	Output	Income	Employment
Agriculture	1.74	1.55	1.36
Slaughtering and meat processors	2.60	6.28	8.15
Poultry processors	2.35	4.22	4.11
Dairy factories	2.46	4.18	5.71
Fruit and vegetable processing	2.04	2.55	2.50
Feed manufacturers	2.33	4.57	6.07
Flour and breakfast cereals	2.47	3.89	5.87
Biscuit manufacturers	1.97	1.92	1.76
Bakeries	1.96	1.82	1.61
Confectionery manufacturers	1.81	1.88	1.99
Sugar refineries	1.47	2.21	2.49
Vegetable oil mills	2.19	6.16	15.36
Misc. food industries	1.88	2.23	2.74
Soft drink manufacturers	1.99	2.01	1.96
Industry complex	1.75	1.78	1.84

higher employment-generating effect. In the agri-complex industries, slaughtering and meat processors once again depict strong employment-generating effects with a multiplier value of 8.15. This is followed by feed manufacturers and the flour and breakfast cereals industry with multiplier values of 6.07 and 5.87, respectively.

The above summary of sectoral measures based on an I-O model of the Canadian economy suggests the potential for generating increases in output, income and employment among the industries in question. These measurements can assist analysts in choosing between such competing alternatives as income generation versus employment generation, for example. The usefulness of the measures is quite evident if province-specific multipliers for agriculture, the agri-complex and the industry complex can also be estimated.[9]

Simulation exercises based on input-output models

Operational input-output models are useful analytical tools for studying the effects of various policy scenarios one wishes to simulate. Statistics Canada maintains two of the most often used operational models—the national output determination model and interprovincial input-output model.[10] These models measure the total impact on gross domestic outputs of various industries.

To illustrate, this section reports the impact of $100 million spent on selected agricultural commodities (hypothetically, it could represent CIDA's Food Aid Expenditure).

Simulation results based on the open[11] version of the national I-O model based on 1979 data (in current dollars) are summarized in Table 4.5. The expenditure was incurred on the following commodities:

007 – Unmilled wheat	$ 60 million
008 – Corn	2 million
070 – Cheese, milk powder	5 million
090 – Wheat flour	10 million
104 – Vegetable oils and crude fat	15 million
410 – Vegetable oils other than refined corn oil	8 million
Total	$100 million

TABLE 4.5 IMPACT OF $100 MILLION SPENT ON SELECTED AGRICULTURAL COMMODITIES (NATIONAL I-O MODEL, 1979: OPEN VERSION)

Industry	Total domestic output	GDP at factor cost	Total employment
	(thousands of dollars)		number of jobs
001 Agriculture	77,382.2	43,543.4	2,670.9
016 Slaughtering and meat processors	3,814.3	511.6	19.4
017 Poultry processors	40.9	8.3	0.4
018 Dairy factories	5,171.1	1,084.8	35.5
020 Fruit and vegetable processing	108.1	31.2	1.3
021 Feed manufacturers	8,209.7	1,270.6	39.6
022 Flour and breakfast cereals	10,171.6	2,229.8	63.0
023 Biscuit manufacturers	7.8	3.3	0.2
024 Bakeries	19.3	8.9	0.5
025 Confectionery mfrs.	222.1	84.4	2.9
026 Sugar refineries	206.0	35.4	1.1
027 Vegetable oil mills	14,494.1	1,654.1	30.1
028 Misc. food industries	1,603.5	479.2	13.5
029 Soft drink manufacturers	29.4	11.6	0.4
030 Distilleries	45.8	18.7	0.4
125 Mfrs. of pharmaceuticals and medicines	605.8	244.4	8.7
164 Wholesale	3,575.7	2,378.7	97.2
165 Retail	1,393.5	956.7	80.0
Industry complex	43,588.0	16,550.8	482.4
Total	170,688.9	71,105.9	3,547.5

The model assigns these expenditures on commodities first to industries that produce them (via the D matrix); these are the direct effects. Postmultiplication of this matrix by the inverse matrix yields total gross output by industries. Additionally, the model solution also provides income arising (GDP at factor cost) and the total number of jobs that are associated with the total gross outputs. These results are reported in Table 4.5.

A glance at this table shows that an expenditure of $100 million on specific agricultural commodities leads to an increase in total domestic output by about $171 million. The increase in this output gives rise to an increase in income arising of about $71 million. The corresponding increase in the number of jobs required to produce the increased output is 3,547. Since the initial expenditure pertains to the products of the agriculture sector, the increases in output, income and employment are quite pronounced in this sector. The spillover effects are, however, evident in the agri-complex industries and also in the industry complex. Vegetable oil mills, for example, show an increase of $14.5 million in output with a corresponding increase in income of $1.6 million and 30 new jobs. Similarly, the output in the industry complex increases by about $44 million, which leads to an increase of $16.5 million in income and 482 new jobs.

A similar simulation was performed using the 1979 interprovincial input-output model (open). Initially, the expenditure of $100 million on the same set of commodities used for the national model was assigned to various provinces according to their existing output proportions. In a manner analogous to the solution of the national output model, the total impact of the specified expenditure on the gross outputs of provinces in question was obtained. Corresponding increases in income (GDP at factor cost) and employment were also calculated for each of the provinces.

Table 4.6 reports increased gross production by province and industry. As in the national model, the agriculture sector shows the largest increase in production interprovincially. The relative increases in provincial production are, of course, functions of a province's specific share of agricultural production in the overall provincial economy. Saskatchewan and Alberta show, relatively speaking, a higher impact in agriculture—77% and 50%, respectively. In British Columbia, on the other hand, agriculture shows a rather small percentage increase in production of agriculture (11%). Increases in output of the industry complex are pronounced in Quebec with 33%, Ontario with 37% and Alberta with 37%. For the former provinces, the results are not surprising since they possess a predominantly larger share of the industrial base of the Canadian economy. It appears that Alberta's share in manufacturing activity over the years is on the increase. Among the agri-complex

TABLE 4.6 STATISTICS CANADA 1979 INTERPROVINCIAL INPUT-OUTPUT MODEL (OPEN), GROSS PRODUCTION BY PROVINCE AND INDUSTRY (SHIPMENTS)

Industry	Newfoundland	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon and Northwest Territories	Canada
						(thousands of dollars)						
Agriculture	1	69	38	25	2 229	5 279	9 274	46 355	20 621	462	0	84 353
Slaughtering and meat processors	0	1	0	0	1 348	1 431	493	57	315	84	0	3 730
Poultry processors	0	0	0	0	9	21	7	1	7	1	0	46
Dairy factories	0	61	37	5	2 790	1 950	134	59	198	79	0	5 312
Fruit and vegetable processing	0	1	1	5	6	65	5	5	2	6	0	95
Feed manufacturers	0	3	8	7	772	1 387	598	383	1 042	55	0	4 255
Flour and breakfast cereals	0	0	212	0	2 582	3 991	907	1 162	1 236	0	0	10 090
Biscuit manufacturers	0	0	0	0	1	5	0	0	0	0	0	7
Bakeries	0	0	0	0	4	9	1	2	3	1	0	19
Confectionery manufacturers	0	0	0	0	11	189	1	12	0	0	0	213
Sugar refineries	0	0	0	30	38	69	19	0	38	4	0	198
Vegetable oil mills	0	0	0	0	0	4 680	2 578	2 285	5 626	0	0	15 169
Misc. food industries	0	0	5	11	70	1 221	46	3	15	60	0	1 432

Soft drink manufacturers	0	0	0	0	4	8	4	2	15	1	0	35
Distilleries	0	0	0	0	7	11	5	0	2	4	0	28
Mfrs. of pharmaceuticals and medicines	0	0	0	0	105	368	6	0	6	1	0	486
Wholesale trade	3	2	19	25	457	1 170	458	687	687	215	0	3 724
Retail trade	1	2	5	4	126	230	171	643	389	43	1	1 615
Laboratory supplies	0	0	0	1	9	36	3	17	23	3	0	91
Industry complex	101	42	354	272	5 299	12 892	3 950	8 313	17 923	3 211	52	52 410
Total	107	181	680	387	15 866	35 014	18 659	59 985	48 147	4 228	52	183 306

industries, vegetable oil mills in Ontario show a higher increase (13.4%) than those in Alberta (11.6%). The total impact of the initial expenditure is, however, more pronounced in Saskatchewan.

Corresponding to Table 4.6, the sectoral distribution of income (GDP at factor cost) by province is shown in Table 4.7. It is clear from this table that Saskatchewan generates a relatively higher GDP at $33.8 million. Most of it (87%) is accounted for by the agriculture sector. Alberta is next where most of its GDP of $12.3 million originates in agriculture as well. The industry complex in Alberta, however, accounts for a sizable (33.9%) contribution to its GDP. In Ontario, quite unlike in Saskatchewan, the agri-complex contributes 34% of the total GDP, whereas agriculture accounts for 24%. The industry complex in Ontario is, of course, the largest contributor to the total GDP of the economy—about 42%. Quebec follows almost the same pattern in its industry complex with 32% in the agri-complex industries and 26% in agriculture.

As shown in Table 4.8, the greatest number of paid jobs (348) are created in Ontario, mostly in the industry complex. Alberta and Saskatchewan are next with 304 and 276 jobs created. In Alberta, the number of jobs created in the industry complex is, however, greater than the number in agriculture, whereas in Saskatchean it is the opposite, with 147 jobs created in agriculture vis-à-vis 78 jobs in the industry complex. Among the agri-complex industries, the flour and breakfast cereals industry provides uniformly more jobs in Alberta (31), Ontario (25) and Quebec (17).

Dairy factories provide roughly the same number of jobs (16) in Quebec and Ontario. This is true also of slaughtering and meat processors in these provinces where the number of jobs created is almost identical (9).

Conclusion

Partial sectoral models of agriculture are commonly used in a microeconomic framework to study supply responses, expectation and risk analysis, and demand analysis for livestock and various field crops. Many of these models have been quite successful in revealing the peculiarities and distinct nature of the agriculture sector vis-à-vis the rest of the economy. The interpretation of these models and the resultant empirical findings, in fact, are affected by the behavior of macroeconomic aggregates in the total economy. There is thus an overriding need for an integrated approach whereby the interdependence of agriculture and the rest of the economy is articulated in modeling efforts of the agriculture sector. Input-output analysis is one general equilibrium modeling approach which captures the interdependence of sectors in the economy.

TABLE 4.7 STATISTICS CANADA 1979 INTERPROVINCIAL INPUT-OUTPUT MODEL (OPEN), TOTAL ENDOGENOUS GROSS DOMESTIC PRODUCT AT FACTOR COST

Industry	Newfoundland	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Yukon and Northwest Territories	Canada
						(thousands of dollars)						
Agriculture	0	41	20	16	1 205	2 680	4 709	29 594	12 305	281	0	50 851
Slaughtering and meat processors	0	0	0	0	189	228	71	6	22	17	0	534
Poultry processors	0	0	0	0	2	4	1	0	2	0	0	9
Dairy factories	0	19	8	1	511	419	27	16	46	18	0	1 066
Fruit and vegetable processing	0	0	0	2	1	20	2	3	0	1	0	30
Feed manufacturers	0	0	1	1	67	294	146	137	191	6	0	845
Flour and breakfast cereals	0	0	26	0	269	1 233	70	230	46	0	0	1 874
Biscuit manufacturers	0	0	0	0	1	2	0	0	0	0	0	3
Bakeries	0	0	0	0	2	4	0	1	1	0	0	9
Confectionery manufacturers	0	0	0	0	3	76	0	5	0	0	0	85
Sugar refineries	0	0	0	7	3	7	3	0	14	2	0	36
Vegetable oil mills	0	0	0	0	0	263	687	239	851	0	0	2 039
Misc. food industries	0	0	3	7	20	146	27	1	4	32	0	240

(continued)

TABLE 4.7 STATISTICS CANADA 1979 INTERPROVINCIAL INPUT-OUTPUT MODEL (OPEN), TOTAL ENDOGENOUS GROSS DOMESTIC PRODUCT AT FACTOR COST (Concluded)

Industry	New-found-land	Prince Edward Island	Nova Scotia	New Bruns-wick	Quebec	Ontario	Mani-toba	Saskat-chewan	Alberta	British Columbia	Yukon and Northwest Territories	Canada
						(thousands of dollars)						
Soft drink manufacturers	0	0	0	0	2	3	1	1	7	0	14	
Distilleries	0	0	0	0	3	4	3	0	1	2	0	13
Mfrs. of pharmaceuticals and medicines	0	0	0	0	41	156	1	0	−4	0	0	193
Wholesale trade	2	1	13	17	304	778	304	456	457	143	0	2 475
Retail trade	1	1	4	3	82	162	111	444	251	33	0	1 093
Industry complex	42	13	126	95	2 003	4 669	1 471	2 702	7 346	1 361	18	19 846
Total	45	77	202	149	4 704	11 147	7 636	33 837	21 539	1 898	18	81 255

TABLE 4.8 STATISTICS CANADA 1979 INTERPROVINCIAL INPUT-OUTPUT MODEL (OPEN), TOTAL ENDOGENOUS EMPLOYMENT (PAID EMPLOYEES) (BASED UPON 1979 PROVINCIAL JOB OUTPUT RATIOS)

Industry	New-found-land	Prince Edward Island	Nova Scotia	New Bruns-wick	Quebec	Ontario	Mani-toba	Saskat-chewan	Alberta	British Columbia	Yukon and Northwest Territories	Canada
Agriculture	0.0	0.9	0.7	0.5	18.7	51.1	50.4	147.7	97.3	7.1	0.0	374.3
Slaughtering and meat processors	0.0	0.0	0.0	0.0	9.0	8.9	3.0	0.3	1.3	0.6	0.0	23.2

Poultry processors	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.0	0.0	0.4
Dairy factories	0.0	0.8	0.5	0.1	16.0	15.9	1.5	0.8	2.3	0.7	0.0	38.6
Fruit and vegetable processing	0.0	0.0	0.0	0.1	0.1	0.8	0.0	0.1	0.0	0.1	0.0	1.2
Feed manufacturers	0.0	0.0	0.0	0.0	3.0	7.3	2.5	2.1	4.5	0.3	0.0	19.9
Flour and breakfast cereals	0.0	0.0	0.5	0.0	17.2	24.8	5.8	4.4	30.9	0.0	0.0	83.5
Biscuit manufacturers	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Bakeries	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.4
Confectionery manufacturers	0.0	0.0	0.0	0.0	0.2	2.6	0.0	0.0	0.0	0.0	0.0	2.8
Sugar refineries	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.2	0.0	0.0	0.6
Vegetable oil mills	0.0	0.0	0.0	0.0	0.0	4.3	8.2	4.5	16.9	0.0	0.0	33.9
Misc. food industries	0.0	0.0	0.1	0.2	0.7	10.0	0.4	0.0	0.1	0.5	0.0	11.8
Soft drink manufacturers	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.3	0.0	0.0	0.5
Distilleries	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2
Mfrs. of pharmaceuticals and medicines	0.0	0.0	0.0	0.0	1.6	5.5	0.0	0.0	0.0	0.0	0.0	7.2
Wholesale trade	0.1	0.1	0.7	1.0	13.5	35.2	13.6	17.9	17.1	5.5	0.0	104.5
Retail trade	0.1	0.1	0.2	0.2	4.8	10.3	8.2	20.5	14.8	1.6	0.0	60.7
Industry complex	1.3	0.5	5.9	3.9	70.3	170.5	53.3	78.4	118.4	41.8	0.8	542.2
Total	1.5	2.5	8.5	5.9	155.5	348.0	147.3	276.7	304.2	58.2	0.9	1309.2

The impact matrix (Table 4.A1 of the Appendix) provides a useful analytical tool to study the interdependent nature of the Canadian economy. A glance at this table shows, for example, that a unit increase in the final demand for the products of slaughtering and meat processors stimulates output in the agriculture sector by 73¢. The output of the latter sector is increased by 69¢ as a result of a unit increase in the demand for poultry processors, and so on. A unit increase in the demand for output in agriculture gives rise to increased production by feed manufacturers amounting to 11¢ and by the industry complex amounting to 44¢, among others. Similarly, one can study the total impact of a unit increase in the final demand for other sectors under study.

It is possible to compute, with the help of an operational input-output model, some useful summary measures such as output, income and employment multipliers for individual sectors as well as for the total economy. Based on a national I-O model, the output multiplier for the agriculture sector is calculated to be 1.74. The output multiplier values for agri-complex industries, on the other hand, tend to be higher. Slaughtering and meat processors show a value of 2.60, which is followed by the dairy factories at 2.46. Analogously, income and employment multipliers can also be computed. For agriculture, the multiplier values for income and employment are 1.55 and 1.36, respectively. Like the output multiplier values, slaughtering and meat processors show high values for income and employment multipliers at 6.28 and 8.16, respectively.

Sectoral income and employment multipliers are analytically quite useful in that they reveal income and employment effects of an autonomous expenditure. Although they can assist an analyst in choosing between an income-generating or an employment-creating expenditure program, these are based on the assumption that there are no rigidities in the markets and that the requirements would always be fulfilled. This is crucial when one deals with employment in agriculture, which is beset with seasonal, transient and family (other than paid) workers.

Input-output models (both national and interprovincial) may be used to simulate the effects of an exogenous change (of $100 million) in the expenditure on selected commodities of agriculture. This exercise demonstrates the model's capabilities to answer policy-oriented questions.

The foregoing reveals that the interdependence of the agriculture sector with the rest of the economy can be succinctly articulated in an input-output framework. Input-output models based on this framework are capable of answering a number of policy-related questions. Since they are deterministic in character and are basically demand-driven, the model results should be

TABLE 4.A1 IMPACT MATRIX, 1979

Industry	00100A	01600S	01700P	01800D	02000F	02100F	02200F	02300B	02400B	02500C
00100 Agriculture	1.0945	0.7305	0.6860	0.6098	0.1351	0.3186	0.4800	0.0867	0.1125	0.0856
01600 Slaughtering and meat processors	0.0101	1.2206	0.0124	0.0122	0.0255	0.0829	0.0088	0.0408	0.0260	0.0116
01700 Poultry processors	0.0004	0.0058	1.0284	0.0005	0.0062	0.0012	0.0005	0.0008	0.0007	0.0005
01800 Dairy factories	0.0017	0.0047	0.0020	1.1198	0.0112	0.0094	0.0057	0.0166	0.0229	0.0415
02000 Fruit and vegetable processing	0.0004	0.0009	0.0007	0.0030	1.0508	0.0009	0.0028	0.0091	0.0120	0.0084
02100 Feed manufacturers	0.1119	0.0749	0.0746	0.0625	0.0155	1.1426	0.0516	0.0117	0.0163	0.0098
02200 Flour and breakfast cereals	0.0041	0.0033	0.0028	0.0039	0.0030	0.0233	1.0125	0.0765	0.1549	0.0041
02300 Biscuit manufacturers	0.0001	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002	1.0003	0.0002	0.0003
02400 Bakeries	0.0003	0.0006	0.0005	0.0005	0.0006	0.0004	0.0007	0.0005	1.0008	0.0009
02500 Confectionery manufacturers	0.0002	0.0002	0.0002	0.0033	0.0031	0.0005	0.0013	0.0103	0.0042	1.0332
02600 Sugar refineries	0.0007	0.0009	0.0006	0.0070	0.0235	0.0045	0.0101	0.0470	0.0274	0.0387
02700 Vegetable oil mills	0.0135	0.0207	0.0092	0.0111	0.0054	0.1110	0.0088	0.0162	0.0071	0.0155
02800 Misc. food industries	0.0020	0.0051	0.0031	0.0119	0.0186	0.0111	0.0165	0.0543	0.0545	0.0386
02900 Soft drink manufacturers	0.0004	0.0004	0.0004	0.0004	0.0006	0.0005	0.0005	0.0004	0.0004	0.0003
03000 Distilleries	0.0005	0.0004	0.0004	0.0003	0.0021	0.0042	0.0003	0.0015	0.0002	0.0001
12500 Mfgrs. of pharmaceuticals and medicines	0.0080	0.0055	0.0053	0.0050	0.0023	0.0232	0.0064	0.0015	0.0020	0.0012
16400 Wholesale trade	0.0378	0.0408	0.0472	0.0392	0.0530	0.0540	0.0506	0.0422	0.0503	0.0351
16500 Retail trade	0.0113	0.0264	0.0102	0.0098	0.0094	0.0087	0.0091	0.0068	0.0069	0.0060
18800 Laboratory supplies	0.0006	0.0036	0.0028	0.0029	0.0022	0.0014	0.0011	0.0025	0.0031	0.0019
Industry complex	0.4453	0.4513	0.4670	0.5543	0.6690	0.5275	0.5796	0.5431	0.4583	0.4814
Total	1.7439	2.5967	2.3540	2.4576	2.0372	2.3260	2.2468	1.9688	1.9607	1.8147

(continued)

TABLE 4.A1 IMPACT MATRIX, 1979 (Concluded)

Industry	02600S	02700V	02800M	02900S	03000D	12500M	16400W	16500R	18800L	I
00100 Agriculture	0.0617	0.5997	0.1244	0.0142	0.0531	0.0128	0.0040	0.0226	0.0104	0.0093
01600 Slaughtering and meat processors	0.0020	0.0104	0.0311	0.0045	0.0061	0.0074	0.0020	0.0019	0.0021	0.0065
01700 Poultry processors	0.0002	0.0007	0.0049	0.0006	0.0008	0.0004	0.0003	0.0002	0.0003	0.0009
01800 Dairy factories	0.0009	0.0019	0.0150	0.0028	0.0018	0.0030	0.0009	0.0007	0.0011	0.0025
02000 Fruit and vegetable processing	0.0004	0.0013	0.0096	0.0015	0.0017	0.0005	0.0004	0.0002	0.0004	0.0008
02100 Feed manufacturers	0.0065	0.0621	0.0144	0.0034	0.0075	0.0042	0.0006	0.0024	0.0013	0.0011
02200 Flour and breakfast cereals	0.0005	0.0024	0.0250	0.0007	0.0008	0.0006	0.0002	0.0002	0.0004	0.0006
02300 Biscuit manufacturers	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
02400 Bakeries	0.0003	0.0003	0.0010	0.0004	0.0004	0.0003	0.0003	0.0002	0.0004	0.0009
02500 Confectionery manufacturers	0.0001	0.0007	0.0204	0.0002	0.0002	0.0021	0.0003	0.0000	0.0001	0.0001
02600 Sugar refineries	1.0578	0.0007	0.0401	0.1041	0.0031	0.0023	0.0005	0.0001	0.0002	0.0005
02700 Vegetable oil mills	0.0010	1.0341	1.0623	0.0011	0.0014	0.0012	0.0003	0.0004	0.0004	0.0006
02800 Misc. food industries	0.0015	0.0027	0.0005	0.0146	0.0086	0.0050	0.0008	0.0006	0.0011	0.0019
02900 Soft drink manufacturers	0.0004	0.0007	0.0003	1.1188	0.0008	0.0003	0.0003	0.0002	0.0005	0.0006
03000 Distilleries	0.0001	0.0007	0.0021	0.0005	1.0522	0.0007	0.0001	0.0001	0.0001	0.0002
12500 Mfgrs. of pharmaceuticals and medicines	0.0010	0.0045	0.0412	0.0005	0.0008	1.1274	0.0003	0.0003	0.0015	0.0006
16400 Wholesale trade	0.0574	0.0343	0.0069	0.0240	0.0249	0.0219	1.0235	0.0128	0.0741	0.0342
16500 Retail trade	0.0032	0.0081	0.0264	0.0075	0.0068	0.0075	0.0064	1.0060	0.0098	0.0155
18800 Laboratory supplies	0.0009	0.0014	0.0039	0.0035	0.0023	0.0068	0.0007	0.0005	1.0004	0.0018
Industry complex	0.2769	0.4236	0.4772	0.6857	0.6267	0.6140	0.4720	0.4283	0.4038	1.6744
Total	1.4730	2.1905	1.8838	1.9887	1.8002	1.8185	1.5138	1.4779	1.5087	1.7530

interpreted with caution. One may, however, wish to disaggregate the agriculture sector further in an I-O framework. A logical step would be to distinguish clearly between the livestock and field crops subsectors. Such a disaggregation is feasible. Disaggregation of the agriculture sector should be pursued along product lines to provide the agricultural analysts with a framework in which various costs associated with processing, marketing, transportation and so on can be identified by commodity. This would enable them to analyze agri-food industries within an overall economic framework. Such a goal may be attainable if it were possible to synthesize the I-O database with farm budget data and other pertinent information available at Agriculture Canada.

Appendix: Rectangular input-output framework and associated national and interprovincial I-O models

The Canadian system of I-O accounts is based upon a rectangular format as opposed to the traditional square format. Therefore, the number of commodities exceeds the number of industries in the tabulation of input-output tables.

The basic accounting framework of rectangular input-ouput tables is presented in Figure 4.A2 below.

FIGURE 4.A2 THE ACCOUNTING FRAMEWORK OF RECTANGULAR INPUT-OUTPUT TABLES

	Commodities	Industries	Final demand less imports	Total
Commodities		U	F	q
Industries	V			g
Value-added wages profits taxes		YI	YF	y
Total	q'	g'	e'	

Notations:

V = matrix of the values of output
U = matrix of the values of intermediate inputs
F = matrix of the values of commodity inputs of final demand
YI = matrix of the values of primary inputs of industries
YF = matrix of the values of primary inputs of final demand
q = vector of the values of total commodity outputs
g = vector of the values of total industry outputs
e = vector of the values of total inputs of final demand
y = vector of the values of total primary inputs

Mathematical expression of the Canadian national and interprovincial input-output models (open)

The accounting balance between the total supply of a commodity and its total disposition can be defined as follows:

$$(1)\quad q + m + a + v = Bg + e + X_d + X_r$$

where

q = vector of domestically produced commodity outputs,
m = vector of the value of imports,
a = vector of the values of government production,
v = vector of the values of withdrawals from inventories (value of physical change),
X_d = vector of the values of domestic exports,
X_r = vector of the values of reexports,
e = vector of the values of various final demand categories,
B = matrix of technological coefficients (to be explained below), and
g = vector of domestically produced industry outputs.

The model assumes first that commodity production among industries is allocated according to their observed shares irrespective of the levels of commodity production, or the fixed market shares, such that:

$$(2)\quad g = Dq$$
$$D = V\hat{q}^{-1}$$

where

D = the market share coefficient matrix and
V = the make matrix, which is a matrix of industry by commodity showing the values of industry outputs.

Second, it is assumed that the values of inputs of each industry are fixed proportions of the values of the total output of the industry and are thus independent of the composition of this output to show the industry technology such that:

$$(3)\quad B = U\hat{g}^{-1}$$

where

U = the use matrix, which is a matrix of commodity by industry showing the values of intermediate inputs used by industries.

Combining and rearranging equations (1) to (3), the model can be solved as:

$$(4)\quad g = [I - D\,(I - \hat{\mu} - \hat{\alpha} - \hat{\beta})B]^{-1}De$$

Equation (4) shows the determination of domestic output corresponding to a given level of final demand.

The output, employment and GDP multipliers reported in the paper are based on an impact matrix such that:

$$(5)\quad g = [I - D\,(I - \hat{\mu} - \hat{\alpha} - \hat{\beta})B]^{-1}$$

The results are thus reported in an industry-by-industry format.

Interprovincial I-O model

The interprovincial I-O model used for the simulation exercise in the text is based on a disaggregation of the national I-O model. It distinguishes the output, input, final demand and interprovincial and foreign trade structure for the eleven provinces and territories of Canada. The assumptions used are identical to those employed by the national model. The only additional information, besides matrices D, B and final demand, which are province-specific, is the interprovincial trade-flow matrices for 602 commodities identified for the national I-O system.

The solution of the interprovincial I-O model is therefore quite similar to the one obtained in equation (4), with superscripts *p* referring to identified provinces and territories:

$$(6)\quad g^{p} = [I - D^{p}(I - \mu)B^{p}]^{-1}\,D^{p}\,e^{p}$$

Equation (6) determines provincial domestic outputs, having made allowance for leakages of provincial trade and foreign imports.

Notes

1 The "agri-complex" industries are defined to include: slaughtering and meat processors, poultry processors, dairy factories, fruit and vegetable processors, feed manufacturers, the flour and breakfast cereals industry, biscuit manufacturers, bakeries, confectionery manufacturers, sugar refineries, vegetable oil mills, miscellaneous food industries, soft drink manufacturers, distilleries, manufacturers of pharmaceuticals and medicines, wholesale trade, and retail trade.

2 A detailed description of all the matrices discussed and the derivation of coefficients based thereupon appears in the Appendix to this paper.

3 See Dillard (1984), pp. 85-100.

4 This matrix is obtained by solving the "open" output determination model of the Canadian economy. The latter is explained in the Appendix to this paper.

5 The multipliers discussed in this paper are "partial multipliers" as these have been obtained by solving the "open" I-O model. "Complete multipliers" based on I-O tables can be derived when the households are removed from the final demand side of the tables and

incorporated as production sectors of the economy. This would imply that the household income is spent within the system, thereby generating further economic activity.

6 Income multipliers relate to the sectoral income arising in the sectors in question. The income components are: wages and salaries, supplementary labor income, net income of unincorporated business, and other operating surplus, referred to as gross domestic product at factor cost. Employment multipliers are estimates of direct and indirect (i.e., total) employment changes resulting from a given change in output for each sector.

7 It should be pointed out that the income multipliers reported here are of the Moore Type-I variety. These are obtained by dividing the total increase in income by the direct income. See Moore and Peterson (1955) and Hirsch (1959).

8 Employment multipliers are calculated as the total number of jobs created divided by the direct jobs needed to produce a unit of output; see also note 7.

9 These multipliers, based on the interprovincial I-O model for the years 1974 and 1979, are available. These can be obtained from the author upon request, by writing to Input-Output Division, Statistics Canada, R. H. Coats Building, Tunney's Pasture, Ottawa, Ontario, K1A 0T6, or by telephoning (613) 990-8914.

10 The detailed description of several variants of I-O models is provided in the Statistics Canada (1984).

11 The model is open to imports, household incomes and various other leakages.

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5

A Canadian Agricultural Regional Programming Model

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*Kurt K. Klein and John D. Graham**

Introduction

The prosperity of Canadian agriculture is dependent on efficient resource use and the timely introduction of new technology. Many federal and provincial agricultural programs have been directed at improving the level and stability of farm income through more efficient use of resources. Canada's agri-food strategy aims to enhance land, capital and human resources and to accelerate technology transfers and production adjustments as well as to improve the agricultural industry infrastruture.

Analyses of policies and programs directed toward these goals have been hampered by the lack of a model of the agriculture industry appropriately disaggregated by region. The economic impacts of various agricultural policies can differ widely according to regions because of the tremendous differences in production opportunities, farming methods and structure of the agricultural resource base in the various regions of Canada.

Data contained in Table 5.1 show selected crop yields and expenses for four regions in Saskatchewan in 1982. Notice that wheat yields varied from 26 to 35 bushels per acre and that barley yields varied from 41 to 55 bushels per acre. Farmers in the northeastern part of the province summerfallowed only 21% of their land, whereas farmers in the southwest summefallowed 43% of their land. On the expenses side, farmers in the northeast spent more than four times as much per acre on fertilizer as farmers in the southwest. Farmers in the north who spent much more on fertilizer and agricultural

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TABLE 5.1 SELECTED CROP YIELDS AND EXPENSES, VARIOUS REGIONS OF SASKATCHEWAN, 1982

				Amount	Expenses per acre seeded				
Region	Crop district	Wheat yield	Barley yield	summer-fallowed	Seed	Ferti-lizer	Chemicals	Fuel, oil	Repairs
		(bushels per acre)		(percent)			(dollars)		
SE	1	26	41	37	2.08	4.24	4.30	11.83	9.00
SW	4	29	48	43	1.53	2.99	3.53	11.45	10.05
NW	7	35	55	39	1.32	7.68	6.64	10.50	8.66
NE	8	31	50	21	2.34	12.14	7.78	12.34	8.48

Source: Statistics Canada, National Farm Survey

chemicals (and so had higher yields) than their counterparts in the southern regions surprisingly had lower expenditures on fuel, oil and repairs. This would indicate that they may have had newer machines or used different production methods than farmers in the south.

The economic impact of any initiative in agricultural policy or technology can be expected to differ among the regions in which the program has been introduced. Furthermore, indirect economic impacts can often be expected in other parts of the country. Analyses of these differential economic impacts requires a regionally disaggregated economic model.

In the late 1970s, Agriculture Canada began developing a regional agricultural model (nicknamed RAM). This model was to have the capability of analyzing a wide arrray of policy or technological changes as they affect the various commodity and regional sectors within agriculture. The model was never satisfactorily completed. There still is not available a comprehensive regional model of Canadian agriculture that may be used to analyze some of the important issues facing the agri-food sector.

A different regional model of Canadian agriculture now is under construction. It is sufficiently different from the RAM to warrant a new acronym—CARP, for Canadian Agriculture Regional Programming model. The CARP model is not as ambitious an undertaking as that envisioned for the RAM. However, with fairly minor modifications, it will have the capability to analyze many questions on resource use.

The objectives of this paper are to:

— present analytical requirements of the CARP model;
— discuss alternative methods for modeling agriculture at the regional level;
— specify major components, characteristics, and uses of the CARP model; and
— evaluate policy analysis capabilities of the CARP model.

Analytical requirements of the CARP model

The objectives of the CARP model are somewhat modest at the present time. It is being built to analyze the economic impacts of only two possible changes in Canadian agriculture: the introduction of medium-quality wheat in Prairie agriculture, and alternative freight rate structures for moving Prairie grain.

Both issues involve potential changes in crop and livestock production in two different regions of western Canada. Changes may occur in the relative profitability of wheat production compared with feed grain production, or of cereal production compared with livestock production. Similarly, relative profitability in the various soil zones may be affected. It is therefore necessary to have a regional breakdown of Prairie agriculture in order to examine changes at this disaggregated level.

Although the primary impacts of these two changes are to Prairie agriculture, they obviously have indirect repercussions on agricultural production in other areas of Canada. A different freight rate structure for moving Prairie grains could change the relative profitability of livestock production in eastern Canada and in British Columbia. Therefore, the CARP model must have the capacity to analyze the indirect effects on agricultural production and resource use in other areas of the country.

The CARP model must include all major agricultural commodities whose production could be affected by the freight rate structure. These include different qualities of wheat, feed grains (corn in eastern Canada), oilseeds (soybeans in eastern Canada), beef, hogs, dairy products, and poultry.

A transportation component must be included in the model to permit shipments of commodities from regions where there is a surplus produced to regions experiencing a deficit or to export.

Above all else, the CARP model must be capable of being maintained over time to permit future applications to policy and resource issues. This requires a data collection and revision system that is neither costly nor difficult to implement.

Specifically, the CARP model must permit analyses of the following issues. For the introduction of medium-quality wheat, the model should predict:

— expected impacts on regional, provincial and national farm incomes;

— expected impacts on returns to resources in Prairie agriculture;

— expected impacts on crop production patterns outside the Prairie area;

— expected area of hard red spring wheat, medium-quality wheat, and oilseed production in each crop-producing region of the Prairie provinces; and

— expected changes in shipments of grain products from the Prairie region.

For alternative changes to statutory freight rates, the model must show:

— expected area of the principal grains in each region of the Prairie provinces;

— expected levels of input use and returns to resources in each region of the Prairie provinces;

— expected impacts on the grain sector in each province of eastern Canada;

— expected impacts on the hog sector in Atlantic Canada, Quebec, Ontario and the four western provinces; and

— expected impact on the beef sector in each province.

Alternative methods for regional modeling

A number of methods have been used for constructing agricultural sector models. According to McCarl (1982), they can be divided into two fundamentally different approaches: the large price-endogenous sector models, and models that contain large numbers of representative farms.

The large sector models usually divide a country into regions, with each region containing aggregate activities and constraints. Cropping alternatives are represented as single activites. This was the approach used in formulating the RAM. The representative farm approach consists of many farm models in which variables are iteratively solved before an equilibrium is reached.

Both approaches have potential problems. The large sector models often lead to results where the optimal solution contains only a single activity for each region. This is often caused by incomplete specification of actual constraints faced by the farmers who have to make their decisions. Sahi and Craddock (1974) suggest the use of flexibility constraints to force the optimal solution to include a reasonable mix of activities. Hazell et al. (1977) suggest that the incorporation of risk criteria into the objective function can improve the descriptive performance of agricultural sector models quite considerably. The CHAC model of Mexican agriculture, described by Duloy and Norton (1973), is a large price-endogenous sector model. The RAM also uses this structure.

The representative farm approach, though intuitively appealing, has problems that limit its usefulness. Its major advantage is its more adequate representation of actual farm-level constraints. However, finding the optimal solution within the context of national markets and constraints can be a very cumbersome and time-consuming process. The aggregative programming model used for Australian agriculture contains 500 representative farms in 56 regions (see Walker and Dillon, 1976). Farms within each region are further stratified into as many as six farm types and three farm sizes. The representative farm models must be solved independently, then the results incorporated into the spatial equilibrium model. Obvious problems include how to model transfer of resources among farms and regions, how to determine regional input and output prices, and how to recognize aggregation biases.

Sharples (1969) discusses the problems associated with constructing a regional model of United States agriculture.

As an alternative to the above approaches, McCarl (1982) suggests that activites in agricultural sector models be whole farm plans rather than individual cropping activities. Each farm plan involves a set of input and output combinations; at the sector level, plans are selected within the context of total resource availability. Snyder and Overton (1973) suggest a similar approach as a means to reduce matrix size in feed formulation problems. Their idea of a "compacted matrix" model is to solve the least-cost formulation problem for a variety of price conditions. Each solution set to this problem is then specified as a single activity in a compacted matrix model. Under different price conditions, a single fomula or a linear combination of two formulas are selected as representing a minimum-cost combination of feed ingredients. Similarly, McCarl suggests that solutions of a linear programming model of a farm will provide a set of whole farm plans that may be represented as activites in regional or sector models. These whole farm plans are generated for a wide set of factor and product price combinations and each plan represents a feasible combination given the resource constraints of the problem. The approach is not "black box" in nature because microeconomic considerations form the basis of each farm plan. At the regional level, a selection from this set of whole farm plans (or some linear combination thereof) is made within the constraint set of the region.

McCarl argues that the main advantage of this approach is the derivation of "sensible" crop mixes in the microeconomic context and the application of this advantage at the regional level where the model will be solved more easily without the use of flexibility constraints.

As a second-best approach, McCarl also notes that it may be possible to use statistical records to provide a set of historically observed farm plans. Each plan represents an observed combination of inputs and outputs for a particular set of factor and product prices. Using these outcomes in a sector model will require firm models to explain this observed behavior. However, since variations in the constraints of the model can often explain observed results, a limited set of explanatory models may be required. The feasibility of these ideas are being seriously examined in the alternative approaches being considered for the CARP model.

Specification of the CARP model

Regional disaggregation within the CARP model is in line with the National Farm Survey, which is conducted annually by Statistics Canada. This survey collects farm input and output data for 22 regions in the Prairie provinces. These regions are consistent with provincial crop districts and census districts (except for Saskatchewan).

One region is specified for each of the other provinces in Canada. This delineation is adequate for analyzing issues concerning the introduction of medium-quality wheat and the modification of freight rate structures, both of which affect the Prairie provinces directly and the other provinces indirectly. It should be noted, however, that the National Farm Survey collects data from 53 regions across the country. Therefore regional disaggregation could be extended to the other provinces when more detailed analyses are required of programs or policies that directly affect agricultural production in British Columbia or eastern Canada.

The major advantage of dividing regions along the lines of the National Farm Survey is the ease of collecting and incorporating new production and resource data on an annual basis. Procedures can be developed that would permit replacement of selected model coefficients on the basis of results from the National Farm Survey. In addition, the regions also correspond to provincial crop districts, which are the units of analysis most commonly used by provincial departments of agriculture.

The model includes crop, livestock and transportation activities in each of the regions. Cropping activities include the proportional area of two qualities of wheat, feed grains (corn in eastern Canada), rapeseed (soybeans in eastern Canada), other grains, and summerfallow. Improved and unimproved pasture as well as hay activities are specified by region. Beef and hog production activities include use of major feed components for various least-cost diets. The cow herd is specified at the regional level; feeders and hogs are specified at the provincial level. Dairy and poultry include only one activity per province to account for major resource requirements. Other uses of feed grains are determined exogenously.

Transportation activities are defined between producing regions and points of demand. Provincial per capita estimates of demand are used for all final demand commodities. Shipments into or out of a province balance supplies with estimated demand. Transportation activities also include those for intermediate commodities, such as feed grains, rapeseed and feeder cattle.

Available land in each region acts as the major resource constraint to production. The RAM includes several classes of land that corresponds to the

Canadian Land Inventory classification. This separation is not used in the CARP model, primarily because data from the National Farm Survey are not differentiated on the basis of land quality. Labor and capital use are modeled to the extent of data availability.

Evaluation of the CARP model

The CARP model is being built to analyze the economic impacts of the introduction of medium-quality wheat into Prairie agriculture and of alternative freight rate structures for transporting Prairie grains.

With minor modifications, the CARP model will be capable of analyzing many regional development programs, especially those applying directly to Prairie agriculture. Technological improvements that change the input-output coefficients of crop and livestock production could be analyzed. Heavier slaughter weights for hogs or cattle could be evaluated, whether they are induced by changes in the grading system or by changes in producion opportunities. Programs that affect resource prices or availabilities could be examined, for example, forage programs, land use programs, credit subsidization programs, labor use programs, taxes or subsidies on energy, and use of fertilizers or herbicides. Commodity market strategies that change the relative rewards from producing various commodities could be evaluated. Stabilization and subsidization of commodity prices could be analyzed for differential economic impacts on a regional basis.

The CARP model could be extended to include a regional breakdown for the other provinces. This would make for a larger model with greater data requirements, but it would increase the model's analytical capabilities. A further extension could include a finer specification of other agricultural commodities, such as dairy or poultry.

All product and input prices could be developed endogenously. Input-output linkages could be added to link agriculture with other industries. This would permit a more accurate assessment of some of the multiplier impacts following changes in the agri-food sector. A general equilibrium approach may be considered.

It should be remembered that the present CARP model is being developed for the very precise purpose of analyzing two issues affecting Prairie agriculture. This is a beginning. If sufficient interest is forthcoming, many improvements to the CARP model can be made. If other sectors and commodities are added, if prices are made endogenous and if the model is linked to other industries, there would be justification in proclaiming it a Generalized Agricultural Regional Programming model. Then we could evaluate Canadian agriculture—*according to GARP!*

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6

The Structure and Policy Analysis Capacity of the Small Annual Model (SAM)

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*Jack Selody and David Rose**

Introduction

SAM is the product of several years of work by a Bank of Canada special studies research team whose objective was to build a complete, consistent, and simple macroeconomic model of the Canadian economy useful for simulating macroeconomic policy and structural change over the medium term. The model was envisioned to integrate the short-run realities of business cycle dynamics with the theoretical insights and longer-term properties implied by economic theory. A key innovation of the model is an explicit equilibrium or steady-state infrastructure that is well anchored in traditional economic theory.

SAM was not built to simulate agricultural or commodity policies or shocks; agriculture is not identified as a separate activity in the model. For example, agricultural production is treated like any other form of production, and is assummed to use capital, energy, and labor in average proportions using average technology. Consumption of agricultural goods is treated like any other consumption, and the relative price of commodities is assumed to be fixed. International trade in commodities responds to the same signals as international trade in other goods. Financing of agricultural production is treated the same as the financing of other production; agricultural enterprises have the same access to equity and bond markets as other firms, and there is no role in the model for commodity futures markets. Finally, the wage of farm labor responds to the same signals as the wage of other labor, and the rate of return on farm capital is the same as that on other forms of capital. In short, there is no special role for agriculture in SAM.

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To give SAM the capability of agricultural policy analysis—even on a macroeconomic level—requires a satellite model in which the details of the agriculture sector and, more importantly, the levers of agricultural policy are delineated. This paper first provides an overview of SAM. It then offers some comments on what an agricultural satellite model might entail. And it points out some implications for policy analysis of different ways of linking the agriculture sector with the macro model.

The focus of this paper is on ways of linking a model of agriculture with SAM. There is no explicit discussion of the advantages or disadvantages of using a small annual model to link with a detailed agriculture model. Briefly, the advantage of using a small highly aggregated annual model as a companion to an agriculture model is simplicity and economy. The disadvantage is that some quarterly impact effects are not modeled, and some of the detailed intersectoral links (both domestic and foreign) are aggregated away. This said, the discussion in this paper makes it clear that a small annual model provides a good forum for many of the issues now facing agricultural policy analysis.

The accounting structure of SAM[1]

In SAM there are four groups of economic agents: firms, households, governments and foreigners. There are formally three domestically produced goods: primary energy, a nonenergy good and a public good. In addition there is a foreign-produced good that is an imperfect substitute for the domestic good, both in Canada and the rest of the world, and a world supply of energy that is perfectly substitutable for domestically produced energy. Domestic households hold their wealth in four forms: non-interest-bearing fiat money, interest-bearing government bonds, net claims on foreigners, and "equity" claims to the domestic capital stock.

Foreigners, in addition to purchasing the domestic non-energy good, hold domestic govenment securities (denominated in both foreign currency and domestic currency) and direct claims on the domestic capital stock. They also supply other financial instruments, which are the net foreign assets of households. Domestic households consume the domestic nonenergy good and the foreign good, demand financial instruments and supply labor. Firms demand labor, energy, and goods (for investment) and supply goods and equities. Governments demand goods and labor, and supply a public good and financial instruments.

There are six complete markets in SAM, including those for the four financial instruments held by domestic households and markets for labor and the domestic nonenergy good. "Complete" markets are markets with endogenous demand, supply and price determination.[2] There are also a few partial markets in SAM.

The demand for energy is modeled but no explanation of the supply side of the energy market is provided. Although the accounting concepts of energy sector investment (and capital stock), labor usage, inventories, and net exports (except for the imposition of the identity forcing output to be consumed domestically, exported or put into inventories) are retained, these variables are left exogenous. The framework is there, however, for users to provide their own energy sector equations.

The demand for imports is modeled but, consistent with the small open economy perspective, the price of imports in foreign currency is assumed to be exogenous to canada. Any quantity of the import good can be had at the going price.

There is no distinct market for capital goods. The single nonenergy output can be consumed or invested; there is no scope for a separate model of a capital goods price. The user cost of capital is endogenous,[3] but it is determined as part of the mechanism whereby aggregate demand and supply are equated, and is not in a distinct capital goods market.

There is no true market for the public good. As in the National Accounts, ouput of the public good is measured as government wage expenditures. This good enters SAM only at the stage of reconciling the modeled private sector output with the usual gross national product concept. There is no consideration of how consumption of the public good influences private sector behavior, but the income generated from the activity is fully integrated into private sector accounts, as are the consequences of the financing of the wage expenditures.

Household labor is used in the production of energy and the public good, as well as in the production of the nonenergy, private sector good. Labor is taken to be homogeneous, however, and there is only one overall market for labor and one endogenous wage.

The six complete markets, together with the three identities linking asset prices with capital income and capital gains, determine eight prices and real rates of interest as well as the value of financial wealth. The system is fully simultaneous and the endogenous variables cannot be assigned to particular equations or even to particular markets. The normalization rules used in the model code are, in principle, arbitrary. The eight prices and rates determined are: the real wage, the real exchange rate, the market price of outstanding bonds, the market price of equities, the real cost of (and return to) capital, the real interest rate on bonds, the domestic price level, and either the real domestic return on foreign assets or the expected future exchange rate (one implies the other, given the exchange rate and the exogenous foreign interest rate). Throughout this paper, "exchange rate" refers to the Canadian dollar price of foreign exchange.

The markets of SAM

The product market

In the market for the domestic nonenergy good, gross output is made a function of capital, labor, energy use, and an endogenous level of capacity utilization. The growth of potential output is determined by exogenous population growth (translated to labor supply growth through an endogenous participation choice by households) and exogenous Harrod-neutral technical progress. Long-run factor demands of firms are derived from a formal framework of static cost minimization, with constraints of zero excess profits and full employment of labor imposed on the aggregate solution. Short-run factor demands not derived from a formal optimization problem are influenced by the desired long-run position, and also by the state of the cycle (in particular, aggregate demand).

Aggregate demand for the domestic nonenergy good comes from domestic households, governments, foreigners and firms in both domestic sectors. Government demand and energy sector investment demand are essentially exogenous. Export sales are made a function of relative prices and the scale of potential output (a domestic supply approach), with foreign demand having a significant short-run cycle effect. Demand for nonenergy sector investment comes from the general system of factor demands. In addition to a tendency to adjust to the long-run optimal capital stock, investment is influenced in the short run by the state of excess demand (an accelerator mechanism) and some financial variables.

Household consumption demand comes from a formal intertemporal, optimization problem, with several disequilibrium features added. In particular, according to the estimates we have made at the Bank of Canada, the level of excess real balances has a pronounced influence on consumption demand. This effect arises because households use money balances to buffer shocks and willingly move away from their long-run money demand function to stabilize other choices such as flow consumption. The model of household consumption demand explains the overall level of consumption.

To provide the net demand for domestic goods, imports are deducted. The quantity of imports is specified to depend on the scale of domestic activity, relative prices, and a measure of domestic capacity utilization (to capture cyclical import substitution). It is not necessary to think of imports as being "consumed" rather than "invested"; in SAM, there is no explicit treatment of the split.

In the market process, any excess of flow supply over flow demand goes into inventories. There are strong feedback mechanisms from the state of inventory stocks (relative to desired stocks) to other variables in the system, including prices, factor demands and capacity utilization. Although the price level is determined by the whole system in the long run, it is reasonable to describe SAM's short-run price dynamics as representing response to two sorts of excess demand. First, there are measures of excess demand in the product market itself. Second, there is a measure of the state of excess demand in the money market, calculated by comparing the current price level with that consistent with long-run, real balance preferences. This latter effect captures both the notion that markets tend to adjust toward equilibrium, and the more specific point that an excess supply of money signals a latent excess demand for goods.

A demand shock entering the system is met in the first instance by inventory buffering and supply response through variation in capacity utilization. The larger and more persistent the shock, the greater the effect on factor usage. For purely nominal shocks, the ultimate effects reflect virtual monetary neutrality in SAM. Real demand shocks have permanent effects on output, but only to the extent that the induced changes in real wages and other variables call forth higher levels of labor supply. As the SAM labor supply function permits only limited scope for such response, the long-run solution is said to be essentially supply-determined, with most of the necessary response consisting of real relative price and real interest rate responses sufficient to reconcile demand with potential output.

Financial markets

In the financial asset markets, demands are specified as a desired allocation of financial wealth across the four instruments, the proportions depending on relative expected rates of return.[4] Asset supplies are specified using the identities describing sectoral financing requirements. Firms issue equities to finance capital formation; governments issue bonds to finance expenditures not covered by tax revenues or new money provided by the central bank. The supply of equities to the domestic market is influenced by the direct investment decisions of foreigners. Similarly, governments can sell bonds to foreigners, and it is the governments' financing requirement, net of such sales, that determines supply to the domestic market. The supply of net foreign assets comes from the balance of payments identity and reflects the cumulation of capital flows not otherwise accounted for (that is, in government transactions or direct investment). Sectoral flows of funds are completely accounted for in the above system.

The asset supply and demand equations, combined with identities that express asset prices as present values of expected future capital income or capital gain, "determine" a system of asset prices and yields. Included is the price of foreign exchange. Recall, however, that the asset system, being part of a fully simultaneous model, cannot determine anything independently of the other equilibrium conditions.

It is not correct to view asset supplies as being passive in the above process simply because the sectoral financing identities are recognized as part of the system. On the contrary, the same optimization process that determines investment behavior, for example, provides a behavioral content to equity supply. Similarly, there is absolutely no reason why the supply of bonds must be residual in the long run, with expenditures and taxes exogenous and governments simply accepting the deficit consequences. Indeed, although this view of the process can easily be simulated using SAM, our default simulation rule for government finance stipulates that tax rates are adjusted in the long run such that new debt is willingly taken up as the economy grows, without disturbing domestic real interest rates. In SAM, financial instruments are not perfect substitutes and so asset supplies are important in determining rates of return.

The labor market

Household labor supply from the formal, intertemporal model (with some added disequilibrium effects) must be reconciled with the combined demands of government and the energy sector (both exogenous, essentially) and the endogenous nonenergy sector. The labor market, unlike the asset markets, does not clear in every period. Involuntary unemployment can exist in the short run for reasons not formally specified in the model.

In the long run, the real wage is set consistent with full employment and the other general equilibrium conditions of the system. It grows with Harrod-neutral technical progress. In the short run, a market process operates that allows the usual unemployment and inflation expectations effects, as well as a tendency to move toward a computed general equilibrium solution.

In the long run, the labor market will clear at a "natural" rate of unemployment that is exogenous to the model. We do not wish to imply that there are no potentially interesting links between macroeconomic variables and the long-run equilibrium level of unemployment. It seems to be generally accepted in the literature, however, that the first layer of "explanation" of the long-run rate must come from microeconomic theory (for example, search costs), particular institutions (the rules of the welfare system) and other things (such as demographics). We think of these "micro" influences as providing an exogenous component of the natural rate, a value essentially independent of the macro variables on which we are focusing. But there is another dimension to the natural rate that can be endogenous in SAM. Although we have chosen to characterize the standard version of SAM as providing an endogenous labor supply participation rate, conditional on a fixed natural rate of unemployment, the same theoretical structure, with some minor modifications, can provide an endogenous labor suply and natural rate, conditional on an exogenous participation decision. Household preferences provide one restriction on the labor supply nexus and either the natural rate of unemployment or the participation rate must be determined outside the model.

In the long run, there is no trade-off between inflation and unemployment in SAM. Any level of inflation is consistent with the natural rate of unemployment once expectations have adapted and adjustment is complete. In the short run, however, to attain a zero inflation rate from an inflationary starting point would likely require a much higher rate of unemployment than the long-run equilibrium rate. This could be called the short-run, noninflationary rate of unemployment. In the short run, the system contains many inertias that prevent rapid adjustment of even purely nominal aspects of equilibrium. The nature of the short-run trade-off facing policy makers and the level of the short-run value of unemployment consistent with zero inflation are endogenous concepts in SAM. In the exploration of short-run policy options, the model has something important to contribute precisely because the exogenous natural rate and absence of trade-offs between inflation and unemployment are features of only long-run equilibrium states of the world.

Long-run equilibrating mechanisms in SAM

We have said that SAM is a model with a fully articulated steady state and that the model's dynamics are such that convergence to steady state is guaranteed. It is useful to ask what mechanisms in the model serve to assure that this is so. In this section, we concentrate on the "existence" part of the question. The discussion is not intended to provide a formal proof of the existence of a steady state in SAM, nor is it intended to be complete (in the sense of discussing every aspect of steady state). Rather, the discussion is intended to give the reader a good feel for how the major macroeconomic variables in SAM are determined in the long run.

Conditions necessary and variables to be considered

To attain a steady state in SAM the following conditions must be satisfied:

— the labor market must clear at the equilibrium or natural rate of unemployment;

— the functional distribution of income must satisfy the zero-excess-profits condition;

— the full-employment potential output must be demanded and must be produced with optimal factor proportions and normal rates of capacity utilization;

— inventory stocks must be at desired levels;

— the rate of capital formation must be consistent with desired real savings that are supplied by domestic residents and foreigners;

— savings flows must be consistent with asset stock preferences both in terms of total wealth and the composition of wealth; and

— each asset stock, including money and net claims on foreigners, must be willingly held and not cause real consumption or capital accumulation to deviate from the stable growth path.

Of course, these are not all independent requirements. For example, if the zero-excess-profits condition does not hold, then factors cannot be optimally employed and aggregate demand cannot be consistent with potential output without violating some other equilibrium condition. Variables that adjust to assure that a steady state will be attained include the real exchange rate, the real return on capital, the real wage, and the nominal price level.

The attainment of nominal steady state

Let us begin with the purely nominal dimension of the discussion. The important restrictions that must be satisfied for the nominal steady state is that real balance preferences be respected and that the stock of real balances be willingly held. We can say very little that is universally valid about the process or the fundamental causation here because, especially in a small, open economy, all the key factors represent policy choices. For example, under a policy of fixed exchange rates, the properties of the domestic nominal steady-state path are determined in the rest of the world. If, however, the nominal level and growth rate of the money stock are set exogenously by the central bank, then real balance preferences imply a long-run restriction on both the inflation rate and the price level, and the exchange rate must adapt. A slightly less stringent procedure would have the central bank maintain its money growth target, but not concern itself with the levels of nominal variables. When such a perspective is adopted in a model, it is generally true that the price level is determined by other factors, and the level of the nominal stock of money adjusts to satisfy real balance preferences. SAM can be used with any of these policy assumptions and various other specifications of policy targets.

Without a specific set of policy rules, we cannot determine the exact nature of the nominal dimension of the steady-state path. For this paper, however, we have chosen to describe the version in which both the level and the growth rate of money are set exogenously. As such, we can be quite specific. Real balance preferences in SAM depend on nominal interest rates and real wealth. Assuming that we are considering a steady state with constant money growth and stable interest rates, steady-state inflation is directly determined by the money-growth choice, and the price level must adjust to satisfy the level of real balance preferences. All other nominal variables, such as the money wage, will adapt to the equilibrium price level so as to maintain their equilibrium values in real terms. A relative purchasing power parity condition will hold in the long run, such that the nominal exchange rate moves to reflect any permanent international inflation rate differentials.

It is important that the reader not be misled into thinking that the price level is solely determined by the money stock, even when the level of money is exogenous. In SAM, the quantity or real balances demanded, and hence the level of prices, is influenced by the real interest rate component of the nominal rate and the level of real wealth (in addition to inflation through the nominal rate). If these endogenous variables change under a shock, the price level will be affected unless the monetary authority neutralizes the shock by changing the level of nominal balances. This does not happen with exogenous nominal balances; so the price level does depend on more than just the money supply. It is fair to say, however, that (given steady-state values for interest rates and wealth and an exogenous money stock) we can "count" the price level as being determined by real balance preferences. Throughout this paper, such "assignment" of variables to particular equations or sectors is referred to as "proximate determination."

The attainment of real steady state

We turn now to the attainment of a real steady state in SAM. A key part of the process involves the planning problem of firms and the imposition of steady-state consistency on these plans. Given a real capital cost, a real energy cost, and the production technology, we can derive the unique real wage consistent with the profit-maximizing behavior of firms and the macro consistency constraints, namely, full employment of labor offered and zero excess profits. We can also compute the long-run output and quantities of factors demanded consistent with the macro constraints and given factor prices. Among the properties of this system is one we require for the discussion that follows, namely, the higher the real capital cost, the lower the equilibrium real wage.

It is important to be very clear that it is not the firms' planning per se that provides the macro results. In the formal micro theory, firms are not assumed to be superrational, or to automatically plan for full employment. Nor do they exploit information about the labor supply function. The basic theory can be characterized as a standard perfect (or atomistic) competition model. We view the imposition of macro consistency constraints on the solution as the macro theory part of the exercise, the implementation of the general idea that markets work. The result is that firm equations are structured as if those firms consider the requirements for a full employment solution in their planning.

The use of the labor supply function in the determination of the long-run values for output and factor usage to which the system is tending shows how a key element of supply determination enters SAM. In long-run equilibrium, the level of output is proximately determined by the labor offered at the equilibrium wage.

It is also worth noting that the observation of excess unemployment in the labor market is not necessarily evidence that the real wage is too high. There is a set of conditions that must hold if the system is to generate full employment with demand sufficient to exhaust potential output. It is not difficult to construct a state of general disequilibrium in which deficient aggregate demand is associated with too low a labor income or human wealth, in turn associated with too low a real wage, contrary to what a partial labor market analysis would suggest. A benefit of the imposition of macro restrictions on the aggregate planning problem of firms in SAM is that we can compute an equilibrium real wage and distinguish among the different possible conjunctures.

The procedure of imposing certain macro consistency constraints on the aggregate firm planning problem is, as far as we are aware, original to SAM. The "theory" of how market restrictions and individual decision making interact is not well developed. Because we have imposed full-employment and zero-profits conditions on the long-run values to which the system is tending, we know that these properties are assured in steady state and we do not have to find some explicit mechanism in a market adjustment process to assure that they hold.

Although we have imposed zero excess profits and full employment on the long-run properties of the supply block of SAM, these are not the only requirements for consistency in the macro model. Moreover, in computing the implications of the two conditions, we do not use a complete, full-model calculation. In particular, the solution takes as given the current "estimate" of the equilibrium real cost of capital, and certain other endogenous determinants of labor supply. Therefore, particular values computed exploiting full-employment and zero-profits conditions, such as the long-run desired capital stock, are not exactly correct until these other "estimates" are themselves correct. On the other hand, our imposition of full employment and zero excess profits is not sufficient to guarantee the other macro consistency requirements. In particular, we have not yet explained how aggregate demand and aggregate supply are equated in SAM.

Three "price" variables are important in the generation of a full, real, steady state in SAM: the real exchange rate, the domestic real capital cost, and the domestic price level. The role of the price level is to generate financial wealth effects and real exchange rate changes. These are important and must be considered in a full description of the process, but since we have already "counted" the price level as being proximately determined by real balance preferences, we will leave it aside for the moment and concentrate on real interest rates and the real exchange rate.

The main mechanism by which the real exchange rate can influence aggregate demand in SAM is the standard one, namely, the current account. The trade equations in SAM have the property that a rise in the real exchange rate (a real depreciation) will increase net exports and aggregate demand. There are other effects through asset stocks and real interest flows, but they can be reasonably ignored for this discussion.

Real interest rates have two direct influences and one important indirect influence on aggregate demand. The direct link through investment demand is standard. We refer to the direct effect of the real cost of capital on the desired capital stock (including the desired stock of inventories) and from that to the level of investment demand. The other direct link is through consumption. A lower real interest rate (and associated lower rate of discount for future income flows) will result in increased market value for certain financial instruments and in a higher present value for a given stream of expected future labor income.[5] Moreover, recall that a property of the general equilibrium solution is that lower real costs of capital are associated with higher values for the real wage. Therefore, the whole level of the expected labor income path shifts up, reinforcing the effect of the lower discount rate. For these reasons, both financial and human wealth increase when interest rates fall. According to SAM's intertemporal optimization model, this will lead households to demand more current consumption and to save less.

The indirect effect of interest rates on demand is through the real exchange rate. Household preferences influence both the level of financial wealth (there is a stock consistent with current planned lifetime consumption) and the allocation of wealth across the financial instruments. The allocation equations restrict how much of each asset households will hold given a set of relative rates of return and a total porfolio value. In SAM, the real return to net claims on foreigners is very closely tied to the U.S. real interet rate. Other domestic rates, such as the real rate on government bonds and the real return on equity claims to the private sector profit stream are linked by high but not perfect substitutability to the return on net foreign assets and hence foreign real rates. Two things happen when there is downward movement in domestic real rates. First, there is asset revaluation. If the bond rate falls, for example, the value of outstanding bond claims rises. Second, since the return on net foreign assets tends to be very closely tied to the exogenous foreign return, this return rises (relative to domestic returns) when domestic rates fall. Both these effects tend to increase the demand for net foreign assets and this, ceteris paribus, pushes up the price of foreign exchange. In other words, the asset system works such that a fall in domestic real rates will have as an associated effect a depreciation in the real exchange rate.

Let us now ask what market forces might cause movement in real interest or exchange rates. Take, for example, the case of a fundamental disequilibrium with excess supply in the domestic product market. With such an excess supply, there is simultaneously too high a flow of real savings from all sources. An interesting if incomplete explanation, insofar as excess supply results in undesired inventory accumulation, views capital formation as being financed by excess savings. Hence, the declining interest rates can be attributed to excess real saving at current levels of demand. If the excess savings are from foreign sources, there would also be upward pressure on the exchange rate. Depending on one's view of the world, this could be due directly to asset effects or to the operation of the nominal interest parity condition (in that downward pressure on interest rates owing to the excess supply shows up as a higher current exchange rate, given expectations for the future exchange rate) or to a rational expectation that the exchange rate must rise to increase domestic demand.

In SAM, we compute whenever we can the equilibrium solutions for variables and use these explicit results in conditioning adjustment processes. In principle, we might be able to extend this approach to the real interest rate and real exchange rate, but we have not been able to find a practicable way to do so. As a workable substitute, we postulate an adjustment process in the usual way; that is, we postulate that, when there is an excess supply of goods, the equilibrium real rate of interest must be lower than our previous best guess. This is imperfect because an excess supply of goods could be consistent with too low a real interest rate, given some combinations of possible severe disequilibria elsewhere in the macro system. In practice, however, we have not found such formal instability a problem.

The above idea is implemented in SAM through the real cost of capital. The real equilibrium user costs of producing capital and inventories fall when there is excess supply in the product market. This, in turn, influences equilibrium real profit rates and other domestic real rates through the asset system. Ultimately, the real discount rate used by households is linked to the average real return on the entire portfolio of assets. But because short-run asset dynamics can produce substantial variation in ex post real returns, only a small weight is given to current market outcomes in discounting the future. More weight is given to a long-term value that moves with the real cost of capital in response to the level of excess demand in the product market.

As explained above, as interest rates change, the exchange rate is simultaneously influenced through asset substitution and valuation effects. As domestic rates fall, the exchange rate depreciates, ceteris paribus. There is also a related mechanism working through the domestic price level. As domestic real rates fall (and real wealth increases), the equilibrium price level declines, assuming a fixed money stock. This constitutes a change in the real exchange rate, since the nominal exchange rate does not respond permanently to such level shifts of prices.

Given that real depreciation of the exchange rate tends to generate a stabilizing response to domestic excess supply, and given the argument that such a response indeed follows from the adjustment processes in SAM, we also have the basis of a "rational expectations" argument for including an excess supply measure in the expected exchange rate equation, but this is not necessary. Moreover, it is important to establish that, just because the structural adjustment equation is written in terms of a real interest rate response to excess product demand, it does not follow that interest rates are somehow determined by an internal balance condition and the real exchange rate by the external balance condition. The system is fully simultaneous. Which "gap" is used in a particular structural equation does not determine the reduced form properties of the model. In fact, given the relatively high degree of asset substitutability in SAM as well as the powerful leverage of real interest rates on aggregate demand, it is entirely possible that, for most real shocks, the exchange rate will move by relatively larger proportional amounts in the adjustment. We do not yet know the balanced answer to this question about SAM's properties.

Disequilibrium dynamics in SAM

The previous section establishes in some detail the factors and processes in SAM that work to assure the existence of a steady state. This is directly relevant in any discussion of disequilibrium dynamics because, when there is a permanent shock to the system, it is precisely the mechanisms discussed above that must operate as the system seeks a new equilibrium path. Putting aside all other sorts of disequilibrium influence for the moment, we can characterize SAM's disequilibrium dynamics as a system of partial adjustment toward equilibrium. We view this as the representation of basic equilibrating forces in markets, and not some superrationality of particular agents. Wherever possible, we implement this idea by using computed measures of equilibrium values and specifying that one of the factors influencing adjustment is a tendency to move toward those values. For example, we use long-run, real balance preferences to compute an equilibrum price level consistent with the exogenous money stock and current best estimates of the steady-state levels of variables determining desired real balances. This equilibrium price level is used as one of the determinants of price dynamics; we specify a market tendency to move the actual price level toward this value. Similarly, factor demands reflect partial adjustment toward long-run equilibrium (as well as a variety of other influences).

It is worth repeating that the computed "equilibrium" values are never exactly correct, except in steady state. In each case, not all essential information is incorporated into the calculation. The results are not true full-model solutions, always approximations. Technically, we do not know a way to solve SAM analytically for full equilibrium. But we can solve chunks, conditional on assumptions about certain endogenous variables. This is what we do. Moreover, the system is stable, and the approximate solutions converge on the correct solutions as a simulation progresses.

We interpret our approximations as reflections of portions of the real world. It seems to us that it strains credulity to claim that plans are always formulated in the light of full information about the steady state. Moreover, we feel that such information or planning problems are an important source of cyclical behavior. Our procedures allow us to introduce this idea into SAM, albeit in a somewhat ad hoc manner.

In summary, an important part of disequilibrium dynamics in SAM is a general tendency to adjust toward full equilibrium. This can be offset in the short run by other factors, but it ultimately dominates. Even in the absence of complicating factors, adjustment to equilibrium need not be rapid, reflecting the real costs of adjustment and other inertias in the system.

Deliberate buffering behavior

In the real world, the economy is subject to a continuous stream of shocks, both permenent and transitory, and no one would expect to observe states of full equilibrium. This very fact leads us to conclude that it is important to build into a model explicit behavioral response to shocks. That is, in an uncertain world, it is certain there will be surprises. Rational agents will develop institutions and response mechanisms for such surprises. In SAM, we provide two explicit mechanisms that firms can use to buffer shocks and to alleviate the costs of cycles in factor usage and output. These are the use of inventories as a buffer stock and the use of explicit variation in capacity utilization to limit the final flow excess supply of goods. We also specify that households use financial assets, especially money balances, to buffer shocks to their income flows or balance sheets so as to limit disruptions to flow consumption.

Expectations errors

The previous section deals with information problems, wherein plans are not formulated on exactly correct evaluations of steady state. There is a parallel set of related effects that arise through expectations errors. In SAM, expectations are forward-looking. They are generally formulated as average expectations about the variable over some horizon relevant to the decision. Thus, expectations errors are notionally distinct from errors about the steady state. They involve difficulties in anticipating the dynamic path as opposed to the end point.

Although our specification of how expectations are formulated has some unique features, the ways they influence behavior and market solutions are, in the main, standard. For example, expectations of inflation influence wage and price dynamics, interest rates and the exchange rate. Inflation expectations are very important in dynamic processes in SAM. They provide a major source of the propagation and prolongation of cycles through their influence on wages and prices.

Confusions, misconceptions and miscellaneous interdependencies

Generally speaking, we avoid basing model properties on irrational behavior, permanent illusions and so on. However, the absence of formal theory about optimal dynamic behavior, both in SAM and more generally, leaves little clear guidance as to what is "irrational" in the short run. We sometimes add variables to dynamic equations in a form such that they disappear as the system converges on full equilibrium, because of a particular interest in a short-run property or because others have found the effect empirically useful. For example, we add to labor demand a short-run sensitivity to the extent of wage disequilibrium. If labor is relatively cheap in the short run, our results suggest that more labor will be demanded than the long-run signals would indicate. This is not an expectations error or a planning error, though it might be considered as a case of deliberate buffering. There are a few such examples in SAM of effects that do not fall clearly into one of the categories above.

In particular simulations, we sometimes add confusions and misconceptions about shocks as an explicit part of the experiment. These then become temporarily part of the dynamics and can dominate the process of adjustment. SAM's dynamics are very much predicated on the processing of information. Because of the model's emphasis on forward-looking behavior, an explicit introduction or errors can have significant consequences.

Agriculture in a small macro model: A SAM perspective

In this section, we present some of the issues involved in linking an agricultural satellite model with the macro structure of SAM. We start the discussion with the simplest form of link, and move to the more complex. In each case, we give an example of how the policy analysis capabilities of the model increase along with the complexity of the model's structure.

Commodities as a separate good in international trade

Here we recognize that international trade of commodities is different from that of other products. To implement this idea in a model such as SAM, it would be necessary to specify the model's import and export equations to be exclusive of commodities, and modify the balance of payments identity to include international trade in commodities as separate entries. For this to be the only link to the macro model requires the assumption that commodities have unique characteristics in international trade, but have similar characteristics to nonagricultural domestic goods in production and domestic consumption. The simplest way of implementing this link is to assume that the commodity for export is not consumed domestically. With this assumption, the international price of the export commodity can change while the price of domestic consumption remains unchanged.

Identifying international trade in commodities as a unique force would expand the analytical capabilities of a satellite model combining macro and agricultural policy. It would allow analysis of the direct effects of a change in the exchange rate on commodity prices and farm goods in world trade as well as on farm incomes. It would also allow analysis of the transmission of commodity price booms through the exchange rate and balance of payments and into the agricultural sector.

Commodities as a separate good in consumption

Here we drop the assumption that commodities are like any other good in domestic consumption. The importance of dropping this assumption is that it introduces commodities as a good that competes with other goods in domestic consumption. Moreover, it is necessary to specify how the relative price of commodities to other types of domestic consumption is determined in the long run. Essentially, there are two choices. It could be assumed that the relative price of commodities is exogenous in the long run, given either by conditions in world markets or by government policy, that is, to maintain a target for farm income. In this case, imports of commodities would move to just satisfy demand in the long run. Alternatively, it could be assumed that the relative price of commodities and other goods in total consumption.

The introduction of commodities to domestic consumption would produce an extra relative price in the model that would produce an additional set of short-run price dynamics. It would be necessary to model how commodity price movements interact with other price disequilibria. This would involve both a model of how commodity price movements influence prices generally and of how a change in the general price level would pass through commodity prices.

Two types of policy issues can be addressed with the integration of agriculture into the consumption sector of the model. The first are questions which ask how commodity prices influence the aggregate price level. The second are questions which concern the real commodity price and in particular ask how different ways of manipulating this price influence the consumption split between commodities and noncommodities. Also involved are questions about how pricing policy helps determine agricultural rents and farm income.

Commodities as a separate good in production

In order to introduce commodities as a separate good in production, the factor markets may be segmented, or this segmentation can be combined with differentiation of the production technology for agricultural goods. Either case would require introducing another factor of production, namely, land. In SAM, there are three factors: labor, energy and capital. The introduction of land as a scarce resource would put a long-run constraint on agricultural production, much as the availability of labor puts a long-run constraint on the overall level of production in SAM. The other factors for agricultural production can be introduced into these markets with varying degrees of completeness.

Introducing agricultural employment to the model requires the addition of a relative wage for agricultural and nonagricultural labor. In the long run, this wage will help determine the amount of labor migration between the farm and nonfarm sectors. In the long run, this relative wage may stabilize on a constant, if agriculture production is a constant proportion of total production, if agricultural production is to be produced with fixed factor proportions, and if farm labor generates the same productivity gains as nonfarm labor. In the short run, the dynamics of the labor market will determine whether the agricultural wage leads or lags the nonagricultural wage. Integration of agriculture into the labor market would permit analysis, with the aid of the model, of the effect of wage-setting policies such as minimum wage policies or policies on labor migration between the farm and nonfarm sectors.

Introducing the agricultural use of energy into the model as a separate demand on the factor would follow much the same pattern as for labor, except that the analysis is complicated by the assumption in SAM that energy has an administered price. The advantage of identifying agricultural energy use as a separate factor demand, with agriculture having a different intensity of energy use from that for nonagriculture, is that the analysis can show how energy shocks move resources and production from the agricultural to the nonagricultural sector.

Introducing agriculture as a unique user of capital raises the question of a separate cost of capital for agricultural enterprises, although the purchase price of capital goods would remain the same for the two sectors. An added complexity of identifying agriculture as a separate user of capital is the treatment of potential rents in the agricultural sector. Essentially, there are three choices. We can assume that capital is employed in the agricultural sector until rents are driven to zero; this is the assumption in the nonenergy goods production sector in SAM. Or, we can assume that governments tax away all rents in the agricultural sector, such that the return to capital in agriculture is the same as that in nonagricultural production; this is the assumption in the energy-producing sector in SAM. Or, we can assume that rents in agriculture accrue to owners of land and that, because of property rights, these rents can persist, such that the return to capital in agriculture is permanently higher than the return in nonagricultural production.

With the integration of agriculture into the process of capital formation, the model can analyze policies such as the subsidization of capital formation or the degree to which resources are transferred to farm production. It can also be used to examine policies that affect the distribution of income, specifically, the distribution of income between the farm and nonfarm sectors.

After agriculture has been fully integrated into the factor markets, a separate technology for agricultural production may be specified. The advantage of extending agriculture into the production technology is that it would facilitate the analysis of questions regarding different rates of technical progress among the different sectors. It would also expand and complicate the dynamics of the model since the characteristics of commodity markets differ from those in other markets, especially the dynamics of inventories.

Commodities in asset markets

There are a number of ways to introduce agriculture into the assets markets of the model. Farm equity may be treated as a financial instrument with different risk characteristics and different rates of return compared with nonfarm financial instruments. This treatment would have implications for the cost of capital to farms and, in particular, would influence the amount of farm profits needed to maintain the flow of funds to farms. Such a separation of assets would be needed in order to determine whether government debt crowds out farm debt more than other forms of debt. It would be be needed to analyze policies that change the characteristics of farm debt, say, by making it more substitutable with government debt by guarantees.

An additional way of differentiating farm assets in asset markets is to specify a futures market for commodities. Here the new financial instrument would be the futures contract, which would compete with other financial instruments as a store of wealth. The challange is to link this futures market with commodity pricing. This extension of the model would facilitate analysis of the effect of government regulations on future markets and of how these would affect spot pricing.

An alternative view

What we have described is but one view of how an agricultural model can be integrated with SAM. It involves adopting a view that the aggregate level of economic activity in an economy is determined by the macro structure of the model, and that the role of the agricultural model is purely an allocative one. A different view is that the SAM macro structure determines the level of nonagricultural economic activity, and that the agricultural model determines agricultural-based economic activity. In this case, the overall level of economic activity is the sum of the two sectors. This view allows the agricultural model to be quite distinct from the macro structure, with feedback between the models limited to certain key channels. For example, the exchange rate would be a key link between the models; it would influence the terms of trade and the quantities of imports and exports in the macro structure and it would influence the price of farm output and farm income in the agriculture model. Investment in agriculture is another key link; it translates into a demand for the production of the macro sector and it influences the level of production in the agricultural sector. Savings is also a key link; households are providers of savings and farmers are users of savings. And wealth links the two sectors; farm income translates into a consumption demand for nonagricultural goods.

Summary

In this paper, we point out that SAM was not built to simulate agriculture policies. We outline the structure of SAM and suggest that the detail of an agricultural model is best placed in a satellite model. We then discuss the different ways in which an agricultural satellite model can be linked with the macro structure of SAM, noting that the closer the link between two models, the more complex the model becomes. This is especially true if the model is to be extended to include all aspects of a two-good world.

Notes

1 This section is excerpted from SAM documentation.

2 Markets fail to clear in the short run in only two of the six markets, namely, the labor market and the output market. For these two markets, we model non-market-clearing price dynamics with a Phillips curve for wages and for prices. U.S. prices influence Canadian output prices because firms sell their output in world markets, and so the price of output is a weighted average of domestic and foreign prices. Households also consume foreign goods, and so the price of consumption is a weighted average of domestic and foreign prices.

3 In fact, the endogenous feature is the differential between the domestic and rest-of-world user cost of capital.

4 The expected rate of return on money is modeled as the negative of the expected rated of consumption price inflation. The expected rate of return on government bonds is the coupon rate on the bond, plus an expected capital gain on the bond as the bond price moves toward its equilibrium. Capital gains on government bonds are possible because the model allows the holding period of bonds to be less than their term to maturity. The expected rate of return on equity is the profit on real capital per unit of equity, plus expected nominal capital gains (the expected rate of inflation), plus expected real capital gains (an expectation that current profit levels will move toward zero-excess-profits levels). The expected rate of return on foreign assets is the U.S. interest rate plus expected U.S. dollar exchange rate appreciation.

5 Expected future labor income is defined as the discounted present value of labor income over a path reflecting the return of the wage rate to its full-employment zero-excess-profits level.

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Linkages Between Agriculture and the Macroeconomy

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Introduction

Early efforts in modeling the agricultural sector during the 1960s did not concentrate on developing the linkages between agriculture and the rest of economy. The relative stability of the economy with low levels of inflation and low real rates of interest was a major factor in leading agricultural economists to model agriculture within a standalone framework. On the other hand, macroeconomists did not include agriculture in their models either. Reasons include the small percentage of GNP generated by the sector, the relatively small percentage of the labor force employed, and the very high degree of government regulation affecting this particular sector. However, as Thompson (1981) mentions, the events of the early 1970s forced agricultural economists to realize that strong linkages exist between agriculture and the rest of the economy, and macroeconomists also discovered that they needed to worry about agriculture. At the time, "no macromodel contained a simultaneous agricultural component, and no agricultural sector model contained simultaneous links to the macroeconomy except through deflated prices" (Thompson, 1981, p. 888).

The objectives of this presentation are twofold: to review the existing literature on modeling agriculture as a sector of the national economy, and to summarize the theoretical structure of a macroeconomic model that emphasizes agriculture and reflects the major interrelationships among the different sectors of an integrated economy. It is argued in this paper that, in order to effectively forecast macroeconomic events as well as agricultural outcomes and to adequately investigate different policy scenarios, a fully specified

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model capturing the interface between agriculture and the rest of the economy is needed.

Models in agriculture

In a paper presented at a recent symposium on modeling agriculture for policy analysis in the 1980s, Penson (1981) classifies agricultural sector models into three categories, namely, first-, second- and third-generation models. This classification reflects the evolution of modeling efforts by agricultural economists, and some representative studies of them are discussed in this section.

First-generation models

First-generation models are characterized by their standalone structure. Few macroeconomic variables are included in these models and the farm sector is assumed to have no impact on the general economy "no matter how long the length of the forecast horizon" (Penson, 1981, p. 55). One representative of these models is the National Agricultural Policy Simulator (POLYSIM) developed at Oklahoma State University by Ray and Richardson (1978). This model accounts for several crop and livestock categories and is based primarily on estimated demand and supply elasticities obtained from a variety of sources.

POLYSIM is completely independent from the rest of the economy even though borrowed funds, for example, are becoming more and more important in financing farm expenditures. This model characteristically deals only with flows. This shortcoming prevents the users from analyzing the eventuality of a decrease (increase) in the capital stock due to several periods of bad (good) conditions in the sector. Moreover, users must supply over 100 separate elasticity values to utilize the model, and the studies from which those elasticity estimates are drawn do not have equations with the same structural form as the ones used in POLYSIM. This implies that biased and inconsistent estimates are used in the model (for a discussion of omitted variables in estimation, see Theil, 1971, pp. 549-50). For example, harvested acreage for soybeans in POLYSIM is a function of the prices of soybeans, feed grains, wheat and cotton. However, no single study estimates all these price elasticities simultaneously.

Other first-generation models include the Food and Agricultural Policy Simulator (FAPSIM) developed by the U.S. Department of Agriculture (see Gadson, Price, and Salathe, 1982) as well as the Food and Agriculture Regional Model (FARM) developed by Agriculture Canada (1980). These models are comprehensive in the sense that they can focus on the impacts of more than one particular agricultural policy and can also reflect, partially at least, the indirect effects of a specific policy on other agricultural subsectors. These models are not linked to macroeconomic models, however, and the feedback effects from the rest of the economy cannot be accounted for.

Second-generation models

In a paper presented to the 1974 meetings of the American Agricultural Economics Association, Popkin (1975) cites several ways to improve macroeconomic models in view of the disappointing performance of four leading forecasting macromodels. Among the ways proposed is the development of submodels for major raw commodity markets where the transformation process relating crude, semiprocessed and finished goods and services would be fully described with "stage-of-process" price models. These submodels could then be embedded in a macromodel framework to contribute to better forcasting of aggregate price series. Mackay and Weber (1975) point out, however, that the state-of-process approach "should allow for the potential factor substitution that might occur as a result of relative price changes rather than being the fixed coefficent production type used in input-output analysis" (p. 178). Second-generation models reflect this idea to a certain degree, but are linked to macromodels in a recursive framework. First, a macromodel is used to forecast macroeconomic variables contained in the agricultural sector model. The agricultural model is then solved to generate agricultural variables, and this information is transmitted back to the macromodel through a set of identities.

Two representatives of second-generation models were presented at the 1976 AAEA meetings: the Wharton agricultural sector model reported by Chen (1977), and the AGSEC model reported by Roop and Zeitner (1977). This latter model can also be solved in conjunction with the Wharton Econometric Forecasting Model. The Wharton agricultural sector model is much more detailed than the AGSEC model[1] and it contains four blocks of equations. They are the intercommodity block, the annual crop production block, the income expenditure block, and a micro-macro linkage block. This model reflects the stage-of-process structure proposed by Popkin and considers the three general classes of interface relationships with the general economy by Just (1977). They are:

> a) the interaction of general prices and income levels, agricultural marketing costs, and agricultural prices in domestic demand for agricultural products; b) the interaction of agricultural input markets, which

> are influenced by other economic sectors, with the supply side of agricultural sector; and (c) the interaction of international trade in agricultural and nonagricultural goods in determining trade balances, exchanges rates, and export demand. (p. 137)

Other representatives of second-generation models include the agricultural sector model constructed by Data Resources Inc. (DRI). Eckstein and Heien (1978) utilize this model with the DRI macroeconomic model to evaluate the major causes of the food price inflation of 1973.

A Canadian representatitive is the model of the Canadian Agricultural Economy reported by Chan (1981). This model can be linked to the Toronto Annual Canadian Econometric (TRACE) model developed at the Institute for Policy Analysis of the University of Toronto. This is a very aggregate sectoral model containing only 31 equations. Aggregate agricultural variables such as gross capital formation, agricultural output and prices, total operating expenses, and net farm income can be generated using information on macro variables supplied by the TRACE model. Its second-generation nature is, however, well recognized by Chan when he mentions that "all the agricultural variables, and for that matter the entire agricultural sector, is exogenous in the TRACE model" (p. 276).

In addition to the fact that the linkages between second-generation models and macromodels are recursive, at least two more shortcomings may be mentioned. To the three general classes of interface relationships with the general economy cited by Just (1977), Penson and Hughes (1979) add another one, namely, the financial interactions between the farm and nonfarm sectors. Second-generation models do not account for financial linkages with the rest of the economy. For example, borrowed funds come in large part from the national money market and the commercial banking system. One way in which the general state of the economy has an effect on the farm sector, therefore, is through financial markets. Unfortunately, this linkage, through which farmers interface with the general economy, is not captured either simultaneously or recursively in the models. One exception is the wide use of interest rates in the interest expenses equation. This drove Penson (1981) to note:

> Interestingly enough, some second generation models which project interest expenses in agriculture so that they can project net farm income do so without projecting period-to-period fluctuations in farm debt outstanding. (p. 57)

This quotation also alludes to a second shortcoming of the majority of these models, namely, their use of flows only. Capital accumulation, which is closely related to the potential of the sector, cannot be analyzed. For example, if economic conditions induce reductions in breeding herd size over several years, the impact of a sudden shift in demand may not be appropriately handled by the model because the biological constraint is not included.

Second-generation models are an improvement over first-generation models in that they recognize the dependence of the agricultural sector on the general economy. However, such a limited feedback from these models to macromodels drove Johnson (1977) to conclude that "there must be more to the connection between economic sectors of an economy" (p. 134).

Numerous studies have looked at the impact of macroeconomic events on agriculture, and some of them are discussed below.

Macroeconomic events and agriculture

One frequently posed question relates to the impact of inflation on agriculture. Lins and Duncan (1980) discuss the issue as it relates to the financial performance and structure of the farm sector. One of their results shows that the variation in prices paid on production items is more highly correlated with the inflation rate than is the variation in prices received by farmers. They then hypothesize that greater variability in farm income could be expected in the short run, although the impact on the level of income, especially in the long run, is not clear (pp. 1049-51). Tweeten and Quance (1971) look at the effect of input price inflation on net farm revenue and conclude that: "Farmers are disadvantaged by input price inflation but not as greatly as many, including the authors, have presupposed" (p. 47). Tweeten and Quance caution the reader, however, that the impact of input price inflation is not homogeneous among inputs, so farmers might even benefit from input price increases if the price elasticity of demand for the input exceeds that of the output (p. 47).[2]

Gardner (1981) generates several regression results on real agricultural variables (prices received, prices paid, net farm income, farm wage rate, and farmland price), and concludes that the effect of inflation was never statistically significant. After discussing several other studies, Gardner concludes that "there is no predictable direction in which real farm prices are affected by general inflation" (p. 876). Only two variables in Gardner's study show consistent explanatory power: recession, which is expressed by a dummy variable reflecting the years when real GNP fell from the preceding year's level, and exchange rates. The fact that exchange rates are consistently significant seems to reinforce Schuh's (1974, 1981) thesis that foreign trade linkages are important factors affecting agriculture. Gardner makes the point, however, that his study is not so conclusive, because the exchange rate effect in his model includes the switch from a fixed to a flexible exchange rate system. When a structural shift dummy reflecting the fixed versus floating exchange rate situation is added to the equations, this variable picks up most of the effect, and the exchange rate itself becomes statistically insignificant.

Other applied research, however, is more supportive of Schuh's hypothesis. Fletcher and Just (1975) describe a study in which they test Schuh's hypothesis with an econometric model on U.S. wheat, and note that "the results overwelmingly support Schuh's arguments" (p. 139). Chambers and Just (1981) report on their study of the dynamic effects of exchange rate fluctuations on several commodity markets. Their results show that exchange rates "had a significant real impact on agricultural markets by altering the volume of exports and the relative split between exports and domestic use" (p. 44). They further note that changes in monetary variables (including those associated with open market operations) can have significant impacts on agriculture via the exchange rate (p. 45).

Other studies that relate agricultural variables to macroeconomic events include Gardner (1981) and Schuh (1981), which give good surveys of the literature. A common feature of these studies is that, once again, they assume away the impact that agriculture could have on the macro variables. Tweeten and Quance (1971), for instance, assume that input price inflation is exogenous to the sector. Gardner (1981) does not use a fully specified model in his analysis because: "The dominance of causality from the general economy to agriculture seems plausible" (p. 876). Chambers and Just (1981) assume an exogenous exchange rate and that the levels of inflation, incomes, agricultural input costs and output demand are exogenous to exchange rate fluctuations.

These assumptions are designated as "heroic" by some (J. Ryan, 1972) and "nonrealistic" by others (Schuh, 1981). Since food accounts for about 20% of prices in the Consumer Price Index (CPI) in both Canada and the U.S., and since agricultural output prices determine food prices (see Eckstein and Heien, 1978), agriculture can hardly be considered exogenous to the macroeconomy. Similarly, since a significant proportion of all net exports in both countries comes from agriculture, exchange rates can hardly be considered exogenous to the sector. Thse considerations constitute the basic concerns of those who advocate the development of models that reflect more simultaneity between agriculture and the rest of the economy. Such models constitute the third-generation models, which are now discussed.

Third-generation models

Third-generation models capture the linkages between agriculture and the macroeconomy in a fully integrated and simultaneous fashion. Potentially, these models could be used to evaluate interrelationships among the agricultural sector, the domestic economy and the international trade sector. However, the models are often too aggregated to fully analyze all these complex relationships. For example, with a model including fewer than 40 equations, Shei and Thompson (1979) capture the entire economy. Obviously, with a model of this size, all interfaces among the three sectors cannot be adequately incoporated and, in this case, it is agricultural policies that are not properly included in their model. Similar shortcomings can be found in Lamm's (1980) model, which is even more aggregated with only 28 equations. Another representative of this generation of models is that developed by Prentice (1981). Although this model contains more than 100 equations and provides detailed information on several sectors of the economy, it fails to relate agriculture to credit markets.

A more recent third-generation model has been proposed by Freebairn, Rausser and De Gorter (1982). Their model contains 51 behavioral equations and 36 identities. The impacts of both fiscal and monetary policies on agriculture can be analyzed in a simultaneous framework. Also, the transmission mechanism of farm policies to the rest of economy is included, and exchange rate determination is endogenous and reflects an identity of U.S. transactions with the rest of the world. However, because all structural equations are not reported in the paper, it is difficult to fully evaluate the model. The capital formation process and the accumulation of wealth, for instance, are not clearly identified. Moreover, the models method of handling government interventions seems suspect. Having an estimated government inventory demand function for crops, for instance, is quite questionable, given the U.S. government's role as a residual buyer when market-clearing prices fall below the announced loan rates, and given the efforts of the USDA to reduce surplus stocks through the Payment-in-Kind program. Furthermore, the fact that support prices and diversion payments enter the acreage response equations in a linear fashion precludes the analysis of a gradual withdrawal of government interventions from the sector as well as the resultant impacts on the rest of the economy.

The last third-generation model discussed here is the Commodity-specific General Equilibrium Model (COMGEM). This model has been developed at Texas A & M University during the last several years, and its theoretical structure is presented in the remaining section of this paper.

The theoretical structure of the COMGEM model

The Commodity-specific General Equilibrium Model (COMGEM) has been designed to capture the interrelationships between agriculture and the rest of the economy in a fully simultaneous fashion.[3] The interactions explicitly captured in COMGEM include agricultural demand for and supply of manufactured production inputs; agricultural output, wholesale purchases of food items and final consumption at the retail level; agriculture and the U.S. balance of trade and exchange rates; agriculture and the U.S. financial markets; and agriculture and the government sector (see Penson, 1983, p. 38). The model contains 321 endogenous variables and 129 exogenous variables. All behavioral equations are estimated using the ordinary least squares (OLS) estimator. In their study of this model, Hughes and Penson (1981) examine the iterative instrumental variables (IIV) estimator proposed by Brundy and Jorgenson (1971) but they conclude that OLS performs better in the majority of the equations. Moreover, improvements to a model of this size can be done at a minimal cost when a single-equation estimator is used.

The macroeconomic structure of COMGEM[4]

The basic macroeconomic structure of COMGEM can be derived from adapting a standard textbook model which includes equilibriums for the product market (the *IS* curve), the money market (the *LM* curve) and the labor market (the aggregate supply curve). Based on Walras's law, most textbook models exclude the bond market for ease of exposition. In COMGEM, however, the money market (*LM* curve) is replaced by the bond market (*BB* curve). The basis of the entire model can, therefore, be represented with the following equations:

$$(1)\ Y/P = c(Y/P,\ r_b,\ W/P) + i(Y/P,\ r_b) + g \qquad \text{(the } IS \text{ curve)}$$

$$(2)\ B/P = b(Y/P,\ r_b,\ W/P) \qquad \text{(the } BB \text{ curve)}$$

$$(3)\ P^o = P^{oe} + a(Y - Y_p)/Y_p \qquad \text{(the } AS \text{ curve)}$$

where

Y = nominal gross national income,
P = a measure of the overall price level,
r_b = is the real rate of interest on bonds,
W = the nominal value of wealth, which includes capital stocks, money and bonds (B),
c = real consumption expenditures,
i = is real investment expenditures,
g = real government expenditures,
P^o = is the rate of change in the price level,
P^{oe} = The expected rate of change in the general price level, and
Y_p = potential output.

Since P^{oe} is not observable, the expected level of inflation in COMGEM is assumed to be related to current and past rates of change in the money supply. The change in money supply can be approximated by the government deficit (DEF) minus the change in government bonds outstanding. Using an adaptive expectation process, equation (3) can be restated in an estimatable form as follows:

$$(3^*)\ P^{o} = \theta_m\,(\mathrm{DEF}) + \theta_n(B^{o}) + a\,(Y - Y_p)/Y_p$$

Where

θ = the distributed lag operator and

B_o = the growth rate of government bonds owned by the private sector.

An implication of excluding the money market is that monetary policy is transmitted through changes in government bonds held by the public rather than through changes in the money supply.

Disaggregating the model

Based on equations (1), (2) and (3*) above, the model is disaggregated to reflect six different groups of transactors in the economy. They are: farm operator families (FOF) which receive major attention, other domestic consumers (ODC), nonfarm businesses (NFB), financial intermediaries (FI), government (GOV), and the rest of the world (ROW). FOF act as producers of raw agricultural commodities, consumers of final products, and the residual beneficiary of farm profits. ODC constitute the major group of demanders for products in the economy, own the means by which nonfarm products are produced, and supply labor to final consumer goods produced in the economy, hire labor, and are the major participants in financial markets. FI provide markets which facilitate an equilibrium to be reached between demanders and suppliers of funds. GOV purchases farm and nonfarm goods, hires labor, collects taxes, finances the deficit, and implements monetary, fiscal, and agricultural policies. Finally, the ROW purchases domestically produced farm and nonfarm inputs, government securities, and supplies primary inputs as well as final consumer goods.

The aggregate *IS* curve stated earlier is the summation of the consumption and investment functions of all individual transactor groups. Moreover, consumption is disaggregated into food, consumer durables, and nonfood nondurable goods and services. The investment equations are more disaggregated in the farm sector where they identify separate relations for machinery and motor vehicles, buildings, inventories and land. Only investments in land and capital equipment are identified for nonfarm businesses.

Equilibrium between demand and supply for a given consumption or investment good is reached by simultaneously equating those two functions. The price of the good can then be solved for using one of the demand or supply equations. In general, the supply equations are used in COMGEM to generate equilirum prices and, hence, to estimate inverted supply functions.

Financial markets are also disaggregated in the model, and seven markets can be identified: demand deposits, time deposits, commercial bonds, government bonds, equities, farm debt which reflects individually real estate and nonreal estate debt, and bank loans. FOF are demanders of demand and time deposits and of both real estate and nonreal estate components of farm debt. ODC demand financial instruments in all markets except the farm debt market. NFB act as both demanders of demand and time deposits, government bonds and bank loans. They act as suppliers in the commercial bond market as well as in the equity market. FI demand commercial and government bonds, as well as equity. They also supply time and demand deposits, as well as farm debt and bank loans. GOV supplies government bonds while the ROW is one of the demanders.

With respect to international trade linkages, the balance of trade and the exchange rate are endogenously determinated in reduced form equations. The exchange rate is driven by industrial production in foreign countries, population growth in the rest of the world, the balance of trade, gross national product and the rate of inflation. The balance of trade is related to the exchange rate as well as to the prices and quantities of U.S. exports and imports.

This short summary of the macroeconomic structure underlying the COMGEM model shows that the farm sector is much more disaggregated than the other sectors represented. The underlying structure of farm supply response in the model, the price determination mechanisms, as well as the transmission mechanisms from the farm to the retail level are described below (see also Romain 1983a, 1983b).

Crop production and prices

Output response for crops is disaggregated into seven major commodities produced in the U.S., namely, wheat, corn, oats, barley, sorghum, cotton and soybeans. For each crop, an acreage response equation as well as a yield response, which is treated as a production function on a per acre basis, are specified. They are both related to all implicit rental costs for inputs used in the production process, to the expected farm price for the commodity as well as for other commodities including livestock, and to the government policy variables.

The implicit rental cost for the inputs is used because it is considered a more representative measure than input prices (see Penson, Romain and Hughes, 1981). This measure accounts for the cost and magnitude of debt financing, the tax deductibility of interest payments, the fact that a portion of these inputs are durable in nature and that their capacity depreciates over time, and the decutibility of tax depreciation. Government intervention is represented through two variables: the effective support price and the effective diversion payment. These two concepts were originally proposed by Houck and Subotnik (1969) and by M. Ryan and Abel (1972), respectively. A similar procedure was used to develop the series used in COMGEM.

The expected farm price is based on two other expected price formulations: the expected market price and the expected price under support. The expected market price is based on the assumption that farmers use futures prices when making planting decisions and, in any given period, the expected market price is given by the following expression:

$$(4)\quad EP^m_t = \left[\sum_{j=1}^{3} (P^m_{t-j}/P^F_{t-j})W^j \right] P^F_t$$

where

EP^m_t = the expected market price in period t,
P^m_{t-j} = the actual market price in period $t - j$,
P^F_{t-j} = the futures prices in period $t - j$,
W = the weighting factor,
$\sum_{j=1}^{3} W^j$ = 1.0.

This expected market price formulation implies that farmers weight geometrically the predictive performance of futures prices over the previous three periods and apply this weight to the current futures price when forming the expected market price.

The expected market price given by equation (4) and the expected price under support, which is given by the effective support price mentioned earlier, have been combined in COMGEM to represent the expected farm price. Even though the programming algorithm used to calculate this expected farm price is quite involved, its major characteristics suggest that, when the market is weak, only the effective support price is considered by farmers as their expected farm price. Stronger market conditions causing the expected market price to increase will cause the expected farm price to increase as well. Furthermore, the larger the difference between the expected market price and the expected price under support, the closer the expected farm price will be to expected market price. An interesting characteristic of this expected farm price formulation is *that a gradual withdrawal of government intervention* from the sector can be simulated. A sudden withdrawal can also be simulated, but this case is considered less likely.

The market price determination mechanism reflects economic theory of price determination under regulated markets, since the U.S. government acts as a residual buyer when market prices fall below the loan rate and as a suplier when prices tend to rise above the release price. Total available supply in any period is given by adding imports to the quantity produced domestically and by subtracting farm consumption and variation in free stocks owned by farmers. The quantity demanded by processors is determined by retail prices and input costs, as well as by their beginning inventory. The balancing equation reflects government intervention. If the equilibrium price in the model solution tends to be lower than the loan rate, government stocks increase sufficiently to keep market prices at this lower bound. On the other hand, when demand exceeds the available supply and when the market price rises to the release price, government stocks decrease by the difference between the quantity demanded and the quantity supplied at this price level. However, if government stocks reach a minimum acceptable level in COMGEM, free market forces apply, and the price increases enough for demand to equal supply.

Livestock production and prices

The framework for the livestock equations in COMGEM reflects the dynamic nature of livestock production captured by the lags between the time the decision to produce is made and the time the final output goes to the market. As is the case for crops, once the decision to produce has been made and resources have been allocated, the production process is largely irreversible. The disaggregation in the model is such that categories of livestock and livestock products are explicitly accounted for, namely, hogs, veal, beef and milk.

The optimal stock of breding animals in the model is expressed as a function of all expected agricultural output prices, the implicit rental costs for all inputs and the potential number of animals ready to enter breeding herds. The lagged value of the dependent variable is included to reflect a partial adjustment process. Gross replacement of breeding animals is given by the summation of the beginning stock, the animals that died and the ones that were slaughtered, minus the ending stock. The total crop of the *i*th category of livestock is then related to the beginning stock of breeding animals as well as to gross replacement. The slaughter of breeding animals has the same theoretical structure as the optimal stock equation, although the beginning stock is included to reflect the aging of the existing breeding stock.

The supply of livestock reflects the biological nature of livestock production. Economic incentives are reflected only indirectly. Therefore, most of the supply is determined by previous outputs (with an appropriate lag), the size of the optimal breeding stock and farm consumption. The implicit rental costs of nondurable inputs are also included in the supply equation.

Finally, farm slaughter is treated as a demand for meat. Its structure implies a utility-maximizing behavior. The explanatory variables therefore include the prices of all other goods entering farmers' utility functions as well as farmers' income from all sources, which reflects their budget constraint.

The structure of farmer' expected price for livestock in COMGEM is similar to the expected market price for crops outlined earlier. It is assumed that the prices of the previous three years are weighted geometrically, thus emphasizing recent events. Rather than adjusting the futures price at planting time, however, livestock farmers in COMGEM are adjusting the price they received in the most recent period.

As mentioned above, livestock supply is relatively inelastic in any given period. In this case, processors' demand is better expressed as an inverted demand equation, since adjustment in demand created by changes in other prices relevant to processors must be captured in the price direction (see Heien, 1975). Two processors' demand functions are present in the model through two series of prices for each livestock category: the cull price for breeding animal available for slaughter and the price received for other categories of market animals. These demand functions are related to the available supply, the implicit rental cost incurred by processors, and the retail prices of different categories of livestock products.

Milk production and prices

Milk production in COMGEM builds heavily on the dairy cattle equations contained in the livestock component of the model described in general terms in the previous section. Total output is defined to be the product of average production per cow and the average number of cows on farms during the period. Average milk production per cow is related to the average price received for all milk during the current period, the implicit rental costs of nondurable inputs, and variables reflecting technological and biological improvements to dairy herds. The inclusion of current prices assumes that farmers react quickly to adjustment in the milk program, while longer-run adjustments are made in the optimal dairy herd stock equation, which is related to an expected price for milk.

The expected farm price of milk is again derived using a flexible weighting system on two expected price formulations: the expected market price and the expected price under support. The derivation of these expected prices is similar to the expected market price for crops discussed previously. The expected market price is weighted using ratios showing the evolution of market prices, while the expected price under support uses ratios showing the relationship between prices received and the price support.

The general framework for the determination of market prices and quantities of milk marketed follows the general approach described earlier for crops. The major differences are that two differentiated products are being modeled (fluid and manufacturing-grade milk), the support price program is related to manufacturing-grade milk only, and both retail prices are affected by the final price level of manufacturing-grade milk.

It should also be mentioned that, for both livestock and milk, retail demand and supply are analyzed. Demand functions are analyzed with the assumptions that consumers maximize their utility under a budget constraint and that inverted supply functions are related to the available supply to processors, to the costs assumed in the transformation process, and to the retail prices of sustitutes. Such disaggregation on a commodity basis is not possible for crops for obvious reasons.

This outline of the theoretical structure of a third-generation model shows that its major improvement over earlier models is its ability to examine long-run effects of policy alternatives and/or exogenous forces. This is based on the facts that CONGEM models the interface between agriculture and the rest of the economy in a fully simultaneous fashion, that the structure of the output response equations allows for substitution among crops and/or livestock alternatives according to different economic incentives, and that it explicitly accounts for changes in the balance sheet that affect the sector's production capacity, its economic performance and its financial position. The attention that has been given to the transmission mechanisms for national economic and farm program policy makes COMGEM well suited for use in aggregate policy analysis.

Conclusion

The degree of capital intensity in North American farming has risen rapidly. New technology has been developed rapidly and has also been adopted rapidly. In the process, farmers have had to make a wider use of borrowed funds, thereby increasing their dependency on factors largely determined by economic forces outside the sector, such as the level of interest rates. Increased productivity has made North American farmers more dependent on the rest of the world to purchase the supplies that could not be absorbed by the domestic markets. Again, agriculture has become increasingly dependent on the general performance of the economy, since variations in the exchange rates directly affect farm cash receipts. This effect is also amplified by the increased financial leverage.

A consensus that seems to emerge from the literature is that agriculture can no longer be considered separately from the rest of the economy in the analysis of agricultural and macroeconomic policies.

The need for better-specified models for agricultural policy analysis therefore seems obvious. Schuh (1981) even argues that "there seems no other route to go, despite our desire for simplicity and for models that can be used in a low cost way" (p.96).

The theoretical linkages between agriculture and the rest of the economy have been relatively well defined and agreed upon in the literature. Models that have actually tested the value of developing endogenous variables are scarce, however. The only test that I am aware of is the one conducted by Hughes and Penson (1981) with an earlier version of COMGEM. Their results seem to confirm the theoretical arguments, since they find that the move from a first- to a second-generation model brought about only minor improvements in forecasting ability, while the move from a second- to a third-generation model achieved substantially fewer errors, especially when a longer period of 3 to 5 years was considered.

More tests will have to be made using other large-scale econometric models in order to further validate the hypothesis concerning the value of endogenization. If these empirical tests do not support the hypothesis, the area of endogenization may be discouraged. Problems in this area are numerous, and the results of model builders' efforts do not always measure up to their expectations.

Notes

1 The AGSEC model as reported by Roop and Zeitner (1977) is difficult to evaluate since, as Johnson (1977) mentions:

> The paper by Roop and Zeitner is more a progress report than a complete research project. A sectoral model, which is much more limited than that of Chen and does not perform well on a satellite basis even in limited validation exercises, is specified and then introduced into the Wharton model of the general economy. (p. 135)

2 This conclusion was later challenged by J. Ryan (1972) because Tweeten and Quance (1971, 1972) do not account for the elasticity of substitution between inputs.

3 This section draws on three papers underlying the COMGEM model which were presented at a workshop on agricultural financial projections models and methods, held in St. Louis, Mo., by Hughes (1983), Penson (1983) and Romain (1983a).

4 See Hughes (1983).

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8

Commodity Policy Models: The USDA Experience

*Kenneth C. Clayton**

Commodity policy modeling in the U.S. Department of Agriculture (USDA) reflects the experience with economic modeling in academia and in government more generally. There is a rich tradition marked by increasing sophistication and greater complexity. The development and application of such models have contributed significantly to the available stock of human and analytical capital.

This paper first considers the role of commodity policy models in the USDA context (it should be noted, however, that the models and modeling experiences upon which this paper are based are specifically those of the Economic Research Service). This is followed by a discussion of the current family of commodity policy models being used and maintained in USDA. Finally, it offers reflections on the USDA experience in commodity policy modeling.

Role of commodity policy models

Understanding the role of commodity policy models within USDA requires a bit of institutional background with respect to the policy decision process in the United States. This setting includes the legislative and administrative processes by which policy and programs for agriculture are established.

Consider first the legislative process. The major U.S. farm legislation of today began during the 1930s. The Agricultural Adjustment Act of 1938 first laid out nonrecourse loans, acreage allotments, marketing quotas for basic commodities, and a goal or parity prices and incomes for farmers.

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After the Second World War, the policy debate centered particularly on whether there should be high, fixed parity prices or more flexible price supports that adjusted to supply and demand. In 1965, the first step in separating the income enhancement features of farm programs from price stabilization was taken. Farmers themselves had rejected the notion of rigid marketing controls for wheat a year earlier.

The early 1970s saw a marked increase in the demand for U.S. agricultural commodities. Farm legislation in 1973 was aimed at providing protection for farmers' incomes while permitting commodities to flow in world trade. Loan rates were to be set below market prices. Direct income enhancement—also known as deficiency payments—was to be paid only when market prices fell below a previously specified target level. The target price was to be based on trends in domestic and world production, the cost of production and other factors. By 1977, farmers faced some slippage in prices, and inflation was pushing them into a cost-price squeeze. Farm legislation in that year established a farmer-owned reserve for wheat and feed grains with government assistance with storage and holding costs.

Over the 50-year period from the 1930s to the 1980s, there has been a shift by U.S. farmers toward greater involvement in world markets. Nearly four crop acres out of every ten are now harvested for export. At the same time, fundamental structural change has been occurring within the farm sector. Farm numbers have declined from 6.3 million to about 2.2 million. Of the total present number, the 5% of largest farms produce around half of total output; the 50% of smaller farms produce about one-twentieth of total output. Average farm size has more than doubled to 433 acres.

The percentage of the labor force involved in production agriculture has declined from 26% in the 1930s to just over 3% currently. Labor has been substituted for by other inputs. Inputs purchased by farmers have increased more than twofold while use of nonpurchased inputs has declined by nearly half. Farmers have become much more dependent on the nonfarm sector of the economy and, in return, the general economy has become more dependent on agriculture in many ways.

This increased interdependency has come to be reflected in the policy decision process. For many years, agricultural policy was primarily the domain of the so-called "iron triangle." The USDA in the executive branch, the House and Senate agriculture committees in the Congress, and the major farm groups pretty well dominated the policy scene. In the past decade or two, this has changed substantially. Within the executive branch, major players in addition to USDA now include the Office of Management and Budget, the departments of State and Treasury, and the Environmental Protection Agency as well as several other departments and agencies, depending on the issues involved.

In the Congress, the budget and appropriations committees have become more actively involved whenever federal outlays are at issue and a variety of other committees review everything from trade to environmental matters. Possibly the greatest change, however, has occurred among the interest groups who carry their cases to both the executive and legislative branches of government. Groups and individuals representing consumers, input suppliers, marketers, labor, the environment and other interests have chosen to become involved. These representatives now number well into the hundreds, if not thousands.

Within the general (although sometimes explicit) guidelines established by the Congress for commodity policy, the executive branch implements farm programs. The principal responsibility for this activity rests with the USDA. Typically, however, proposed actions must be reviewed with other executive agencies and departments. The Reagan administration utilizes its cabinet council on food and agriculture for this purpose. One of several subcabinet groups, it brings together the secretaries of Agriculture, State, Treasury, and Commerce plus the Office of Management and Budget, the Council of Economic Advisers, and the Special Trade Representative.

Program options are considered first within USDA. Decisions rest with the secretary and are given input from the undersecretary for commodity and international affairs, the assistant secretary for economics, and others. The Economic Research Service (ERS) provides support to the assistant secretary for economics.

ERS serves as the research and analytical arm of the USDA on matters pertaining to the economics of U.S. and world agriculture. ERS has responsibility for a program of economic research, analysis, and forecasting that is broadly based and national and international in scope. There is a particular focus on crop, livestock, and fruit and vegetable commodities. There is also a focus on the various institutions associated with public intervention in agriculture. Research is conducted which attempts to explain what has been, what is, and what could be in terms of U.S. agriculture, its structure, and its response to various exogenous and endogenous factors, including a host of policy variables.

Now, logically, it may be asked at this point what all this has to do with commodity policy models. The response is really quite simple: the workings of the agricultural economy have become very complex. A host of exogenous as well as endogenous factors affect its performance. Moreover, interests both within production agriculture and in related activities find that they have a stake in its economic health. Private and public decisions hang in the balance based on an understanding of this complex system. Public intervention, particularly, raises questions of direct and cross-commodity impacts. Given the diversity of participants in this process, issues of trade-off and compromise are often of critical importance.

Examining alternative futures for U.S. agriculture, given the importance of world agricultural market and macroeconomic conditions, is clearly a complicated undertaking. Unless the economic behavior of the farm sector with its many and varied linkages is captured in some analytical sense, both private and public decision making becomes an even more difficult activity. Commodity policy models play an important role in supporting a clearer and more precise examination of trade-offs. They can enhance the understanding of interdependencies within agriculture and with the variety of outside forces that affect the sector's performance over time.

ERS has responded to meet this need by developing a set of models that can be used in research on behavioral and structural issues relating to production agriculture as well as the marketing and consumption of farm products. This set of models also supports the understanding and dissemination of current commodity market intelligence. And the ERS set of models permits the economic assessment of commodity programs and policy options. The current family of ERS models is described more fully below.

Current ERS models

ERS has been involved in agricultural sector modeling for quite a long time (see papers by Boss et al., 1977; Boutwell et al., 1976; Farrell and Haidacher, 1980; Haidacher and Matthews, 1977; USDA, 1981; and Womack, 1980). Beginning with the rather simple but pathbreaking single and multiple commodity models developed in the late 1950s and early 1960s, a succession of such efforts can be identified. During the 1960s, considerable effort was placed on developing mathematical programming frameworks for research and policy analyses. By some accounts, too much was attempted with a framework that led to aggregation problems and solutions that were closely conditioned by constraints that had to be assumed exogenously (see Slaughter, 1972). The 1970s saw a shift to econometric frameworks that tended to better capture behavioral relationships. Most recently, ERS has moved to a collection of models that reflect a variety of methodologies, each with strengths that can be capitalized on for purposes of research and analysis.

Four of the principal models utilized by ERS for agricultural sector research and forecasting are highlighted in this section. Included are an annual econometric model referred to as the Food and Agricultural Policy Simulator (FAPSIM); an econometrically estimated Quarterly Model; a mathematical programming model of the U.S. agricultural sector (USMP); and an international agricultural model which focuses on grains, oilseeds and livestock (GOL).

This group of models, while of primary importance to the ERS program, does not cover all models available. Considerable use is also made of an input-output model of the U.S. economy, several of the proprietary model and database services for agriculture and the U.S. macroeconomy, the General Equilibrium Model (GEM) developed at Texas A & M University for farm sector finance analyses, and the CARD Model at Iowa State University for resource-based questions.

The Food and Agricultural Policy Simulator

The Food and Agricultural Policy Simulator (FAPSIM) is an outgrowth of three decades of research (see Salathe et al, 1982). It is designed to enhance and support the economic intelligence and forecasting ability of ERS for the intermediate term and to provide a means for evaluating and quantifying the impacts of alternative legislative proposals and policies on the agricultural sector. Its forerunner, the Cross-Commodity Forecasting System (CCFS), was made operational in the late 1970s. FAPSIM was put on line in 1981 and, since then, has been used successfully in a variety of applications. Currently, the model includes 360 equations, containing 360 endogenous and 265 exogenous variables.

FAPSIM is an annual econometric model of the agricultural sector specifically designed to analyze the effects of agricultural policies and programs on the food and agricultural system. It specifically models government involvement in the agricultural sector through farm commodity programs, federal marketing order and dairy price support programs, and commodity stock storage programs. FAPSIM is capable of analyzing the effect of government policies and programs on farm income, food prices, government expenses, and the supply, utilization, and prices of farm commodities in any particular year.

Exogenous policy variables include individual crop loan rates, target prices, national program yields and acreages, and diversion and set-aside rates. Macroeconomic variables such as population, disposable personal income, food processing wage rates, petroleum prices, and the nonfood consumer price index are also in the model.

Six livestock commodities are contained in FAPSIM (Table 8.1). They include beef, pork, young and other chicken, turkeys, eggs and dairy products. The dairy sector includes fluid milk, butter, and cheese, as well as other processed milk products. Each individual submodel consists of a set of equations used to estimate production, market and retail prices, consumption, and ending stocks. Seven crop commodities are included in FAPSIM: wheat, corn, oats, barley, sorghum, soybeans and cotton. Each crop submodel consists of a set of equations used to estimate production, total supply and demand, price and ending stocks. The soybean submodel also contains a soybean processing component.

TABLE 8.1 LIST OF FAPSIM COMPONENTS

Category	Item
Crops	corn
	wheat
	soybeans
	soybeans
	soybean meal
	grain sorghum
	barley
	oats
	cotton
Government payments	reserve storage
	deficiency
	other
Cash receipts	livestock subcomponents
	crop subcomponents
	total
Production expenses	purchased livestock
	purchased feed
	purchased seed
	fertilizer and lime
	depreciation
	net rent to nonoperators
	other
Consumer price indexes	livestock subcomponents
	crop subcomponents
	food at home
	food away from home
	all food
	all items

(continued)

TABLE 8.1 LIST OF FAPSIM COMPONENTS (Concluded)

Category	Item
Farm income	gross
	net
	net plus change in value of farm inventory
Livestock	beef
	fed
	nonfed
	pork
	chicken
	broilers
	other
	eggs
	turkeys
	dairy
	fluid milk
	butter
	cheese
	nonfat dry milk
	condensed and evaporated milk
	frozen milk products

FAPSIM contains linkages between the crops and livestock sectors and these components of the model are solved simultaneously. Since government policies and programs influence crop prices, government policies also indirectly affect livestock prices and production. FAPSIM explicitly recognizes the involvement of government in the dairy sector through price support operations and milk pricing. The dairy sector is linked to other crop and livestock sectors. This linkage permits FAPSIM to measure both the direct and indirect impacts of dairy policies on the food and agricultural system.

By using behavioral econometric relationships to endogenously determine the response to changes in policy variables, FAPSIM provides a flexible tool for analyzing different farm commodity programs. The model is based on a net returns concept that explicitly bases economic behavior on prices (market and/or government) and costs. FAPSIM makes it possible to estimate the impacts of shocks to the food and agricultural system, such as a change in import or export levels.

FAPSIM has been used extensively to examine alternative farm policies. The model is currently being used to estimate the effects of implementing some of the different policy options that have been discussed in relation to the 1985 farm legislation. As an illustration, the model has been used to examine the effects of implementing different levels of acreage reduction and diversion, adjusting the farmer-owned reserve loan rates and target prices based on alternative formulas using past market prices, and using different methods of determining the support price received in the dairy sector.

The Quarterly Model

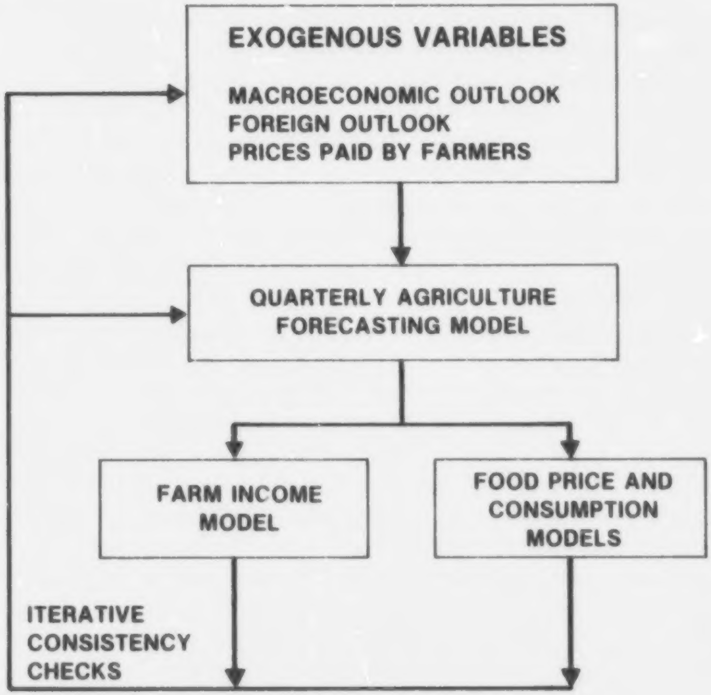
The Quarterly Model of the U.S. agricultural sector has been developed as an integral part of the situation and outlook program and related activities of ERS (see Westcott and Hull, 1985). An important feature of the model is its parallel with the ERS situation and outlook forecasting processes: it has explicit linkages between the crop and livestock sectors, it uses macroeconomic variables as exogenous inputs, and it produces outputs needed to generate aggregate agricultural sector indicators. Because its applications are primarily short-term in nature, the Quarterly Model has been designed to forecast 3 to 6 quarters ahead.

In the monthly forecasting process, model estimates serve as an additional source of information for the commodity analysts to use in making their projections. The model focuses on the major variables important for each commodity and serves as a useful tool for making projections, thereby complementing the work of commodity analysts. Major benefits to the monthly forecasting process are derived from the model because it is computerized and has a quick turnaround capability. First, estimates are available to the analysts early in the monthly forecasting process. Second, last-minute changes during the forecasting process can be easily incorporated into the agricultural sector projections with consistency assured through linkages between the various subsectors.

The Quarterly Model is intended to be a separate component within the larger ERS forecasting system (Figure 8.1). By treating the agricultural sector as a separate component, the variables projected by other analysts and available at the start of the monthly forecasting process—namely, macroeconomic, foreign, demand and price variables—are treated as exogenous inputs to the agricultural sector model. Within the agricultural component, interaction between various subsectors, particularly livestock and feeds, are analyzed. Results from the Quarterly Model can then be used as inputs to independently derived, already-existing models of the major agricultural sector aggregates. Feedbacks and consistency checks can be performed as needed through iteration.

In impact analysis applications, alternative scenarios can be easily run, again with quick turnaround. These scenarios are generated by changing exogenous assumptions, by restricting endogenous responses (using slope

FIGURE 8.1 THE ROLE OF THE QUARTERLY MODEL FOR AGRICULTURAL FORECASTING


EXOGENOUS VARIABLES
MACROECONOMIC OUTLOOK
FOREIGN OUTLOOK
PRICES PAID BY FARMERS
QUARTERLY AGRICULTURE FORECASTING MODEL
FARM INCOME MODEL
FOOD PRICE AND CONSUMPTION MODELS
ITERATIVE CONSISTENCY CHECKS

and/or intercept shifters), and/or by predetermining endogenous variables. Simulation results from alternative scenarios can be compared with the model's base forecast for that month. For example, during the summer of 1984, scenarios were run to assess the impacts of another drought. This was done by altering the exogenous weather variables from the values assumed in the base scenario.

To facilitate its application, the components of the Quarterly Model have been programmed for use on personal computers by commodity analysts. Selected subsectors from the model along with the supporting data necessary to make projections have been put on a spreadsheet (Lotus 1-2-3) operating system. Although this approach does not allow for complete interaction among subsectors as in the full model (which resides on a larger mainframe computer), base forecasts can be quickly made and initial impacts of alternative scenarios can be quickly assessed.

Commodities covered in the Quarterly Model include corn, wheat, soybeans, soybean meal, soybean oil, cattle, hogs, broilers and turkeys. The model is relatively small in scale, although it is large enough to be useful in identifying linkages between the crop and livestock subsectors and in providing input to other models. More commodities, such as dairy, cotton, barley, oats and sorghum, are being included as development continues. Additionally, explicit linkages such as data input and output are being established with other models used in the situation and outlook programs, such as models that explain farm income, food prices and food consumption.

The USMP regional agricultural programming model

The U.S. agricultural sector mathematical programming model (USMP) is a spatial and market equilibrium model designed for general-purpose economic and policy analysis of the U.S. agricultural sector (see House, 1984). USMP assumes perfectly competitive product and factor markets. For specified policy and economic conditions, it estimates equilibrium levels of factor and commodity prices and production at the regional level, as well as the flow of commodity production into domestic, stock and export demand markets. It incorporates regional, detailed production input and risk factors. Like other spatial equilibrium mathematical programming models, USMP is not designed for dated forecasting, but rather for comparative static analysis which has proven quite useful in many types of policy analysis.

USMP possesses a number of important characteristics that allow it to augment the economic and policy analysis capability of ERS. First, it is flexible and permits analysis of a wide range of hypothetical or "what if?" questions or policies. It incorporates supply and demand market detail as well as traditional U.S. government commodity program policy instruments. Second, a regional geographic specification is used which permits analysis of relative regional impacts of government programs and general economic stimuli. Third, the effects of risk and uncertainty on agricultural production are explicitly represented. This is important since production decisions are heavily influenced by expectations regarding uncertain prices and returns, and much of agricultural commodity policy is designed to reduce the effects of market uncertainty. Fourth, the major links between the U.S. agricultural sector and the "rest of the world" are included. This is necessitated by the increasing instability of national and international product and factor markets. Fifth, the agricultural supply components of the model are detailed, allowing analysis, for example, of factor substitution in response to relative price changes. Also, the structure of factor markets is explicit and permits specification change. Sixth, and finally, the model is a functional and usable tool in a real world policy analysis environment. The programming/activity analysis framework permits specification of both the supply and demand sides of the model with a "realistic level of detail" which is critically important for policy analysis. This ability facilitates analysis of impacts of economic and policy changes in terms of variables with which decision makers and policy analysts customarily operate. USMP's specification detail and nonlinear formulation are designed to yield a model containing detailed supply and demand relationships necessary for policy analysis, but small and efficient enough to be inexpensive and to permit frequent use.

USMP is based largely upon cross-sectional and engineering data and shares some common data bases with other ERS policy models. Unlike traditional econometric-based models, it contains relationships for which no time series data exist, and may be used to investigate impacts of events outside the range of historical time series data. The model includes 36 commodities, comprising the principal U.S. crop and livestock commodities: primary agricultural products (such as corn and hogs), intermediate products (such as animal feed rations), and processed products (such as retail cuts of pork) (see Tables 8.2 and 8.3). A mean variance formulation of business risk is specified for the seven major crop commodities. Geographically, the model separates the United States into 10 production regions (see Figure 8.2). Land and labor supplies are specified at the regional level.

TABLE 8.2 LIST OF USMP CROP AND LIVESTOCK PRIMARY COMMODITIES

Crops	Livestock
cotton	fed beef for slaughter (FEDSLA)[1]
corn	nonfed beef for slaughter (NONFEDSLA)
soybeans	beef calves for slaughter (CALFSLA)
wheat	beef feeder yearlings (BFYRLINGS)
sorghum	beef feeder calves (LIVCALF)
rice	cull beef cows (CLBFCOW)
barley	cull dairy cows (CLDARYCOW)
oats	cull dairy calves (CLDARYCF)
silage	milk
hay	hogs for slaughter (HOGSLA)
	cull sows for slaughter (CULLSOW)
	feeder pigs (FEEDERPIG)
	poultry (POULGCAU)
	other livestock (LIVESTOCK)

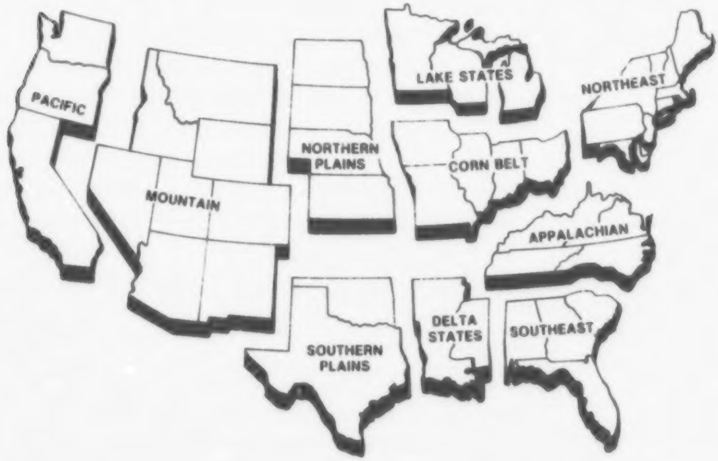
[1] abbreviations used in USMP reports are in parentheses

TABLE 8.3 LIST OF USMP CROP AND LIVESTOCK SECONDARY COMMODITIES

Crops	Livestock
soybean meal (BEANMEAL)[1]	fed beef (FEDBEEF)
soybean oil (BEANOIL)	nonfed beef (NONFDBEEF)
livestock feed grain (FEEDGRAIN)	veal
dairy protein supplement (DPROSUP)	pork
low protein swine feed (SWPROLO)	
high protein swine feed (SWPROHI)	
low protein cattle feed (CATPROLO)	
high protein cattle feed (CATPROHI)	

[1] abbreviations used in USMP reports are in parentheses

FIGURE 8.2 FARM PRODUCTION REGIONS


PACIFIC
MOUNTAIN
NORTHERN PLAINS
LAKE STATES
CORN BELT
NORTHEAST
APPALACHIAN
SOUTHERN PLAINS
DELTA STATES
SOUTHEAST

Additionally, land is separated into crop and pasture classes, and labor is specified by family and hired types. Price-elastic supply functions are specified for land and labor inputs. Some 23 general factor inputs are included in the model with fixed, national-level prices (see Table 8.4). Three commodity final demand sectors are specified separately: domestic consumption, exports, and stocks.

TABLE 8.4 LIST OF GENERAL FACTOR INPUTS

Input	Units
nitrogen fertilizer (FERTN$)[1]	dollars
potassium fertilizer (FERTP$)	dollars
potash fertilizer (FERTK$)	dollars
lime (LIME$)	dollars
other variable costs (OVARC$)	dollars
public grazing land (PUBGRAZ)	acres
custom farming operations (CUSTOMS$)	dollars
chemicals (CHEMICAL$)	dollars
seed (SEED$)	dollars
interest on operating capital (INTOPCAP)	dollars
machinery and equipment repair (REPAIR$)	dollars
veterinary and medical cost (VET&MED$)	dollars
marketing and storage (MARK&STOR$)	dollars
cash ownership costs (OWNCASH$)	dollars
noncash ownership costs (OWNNONCASH)	dollars
management costs (MGMT$)	dollars
land taxes (LANDTAX$)	dollars
general farm overhead (GENFARMOH$)	dollars
variable noncash costs (VARCNONC$)	dollars
irrigation water application (IRRIGAPPL)	acre inches
energy costs (ENERGY$)	dollars
insurance (INSURANCE$)	dollars
land rent (LANDRNT$)	dollars

[1] abbreviations used in USMP reports are in parentheses

Two versions of the model have been developed:

- an aggregate model where each of the 10 regions contains a production activity for each primary commodity produced there, and
- a disaggregate model where each of the 48 continental States contains a production activity for each primary commodity produced there.

Each production activity is an average of production techniques in the geographic area it represents. The aggregate and disaggregate models contain 143 and 542 primary commodity production activities, respectively. Each version of the model contains 25 production activities for secondary or processed commodities which are specified at the national level. The aggregate and disaggregate model tableaus measure 111 by 301 and 185 by 679, respectively.

USMP has been used for analyses addressing a wide variety of topics over the past year at ERS. These include:

- the farm sector impacts of export demand levels and export demand variability as a part of the ERS World Food Study;

— simulations of "conservation land bank" alternatives;
— impacts of technological change in milk, wheat and soybean production; and
— the impacts of removing acreage set-aside requirements on crop production on livestock grazing and production.

Work currently under way includes:
— analysis of national and regional impacts of commodity program alternatives and nontraditional farm program alternatives;
— development of an "advanced base year" model; and
— various technical improvements such as a Positive Quadratic Programming formulation and conversion to a flexible modeling language.

The world grains, oilseeds and livestock (GOL) model

The GOL world agricultural model is an annual simulation model designed for providing mid- to long-term projections of world food supply and demand under alternative world economic assumptions (see Ronigen and Liu, 1983). It is also useful for analyzing the impact of major international economic and policy changes on U.S. and world agricultural trade.

GOL consists of 27 country and/or regional models and includes 20 major agricultural commodities of trade interest to the United States. The country/region models are linked together by a world market-clearing mechanism which solves for equilibrium world commodity prices. The model calculates equilibrium prices, supply, demand and trade quantities for the regions and commodities, given assumptions about supply growth rates, population, income and major quantitative trade restraints.

The GOL model can be viewed as consisting of two major model components: country/region models and a world market-clearing model. Country/region models are, in some case, "detailed" and, in other instances, "simple" (it is also possible to substitute other simulation models as long as they are stable and conform minimally to GOL nomenclature and structure). A "detailed" country model is designed to allow substitution among commodities in both production and consumption. Quantity equilibrium relationships and price balance relationships in the domestic currency are maintained. Domestic prices are then linked to foreign or "world prices" by separate linkage equations. A "simple" model, in contrast, has fewer equations with far fewer cross-commodity links, and directly uses world prices in the supply and demand equations.

Figure 8.3 summarizes the content of the GOL mdoel. A matrix of rows (commodity group) and columns (countries/regions) shows a "1" for each country and commodity for which a set of supply and demand equations exists. Not all country-commodity combinations have equations. Commodities whose country detail is not very significant in world context are not specifically included, in order to keep the size of the global modeling system manageable. The world market is completed for each commodity by a rest-of-the-world region which represents the aggregate supply and demand for these commodities not elsewhere included. Figure 8.3 shows that the global model system has sets of equations for 339 commodity/country groups.

The commodities chosen for GOL include about 80% of the volume of U.S. agricultural exports and are confined to those commodities and to country detail maintained in the FAS-ERS world commodity database. The country/region breakdown is chosen to individually represent the largest consumers and producers for each commodity.

The set of country/region models is linked together and solved simultaneously using the TROLL LINKMOD simulation package. Figure 8.4 summarizes the structure of the world GOL model. Each country model has a set of supply and demand equations for the set of commodities shown in the columns in Figure 8.3. A domestic price is assumed to equal a world price unless an externally imposed trade limit is reached. In this latter case, the internal price changes to clear the domestic market near the trade limit. These trade limits can represent factors such as trade quotas, the ability to pay for imports, or the general capacity to move commodities in trade for each commodity produced by a country. Trade is added up to see if the world market is cleared (net world trade = 0; world supply = world demand). If not, the world commodity price is raised (lowered) if world net trade is negative (positive). The country models take the new world prices and solve again, producing new net trade quantities. This process is repeated until world markets for all commodities are cleared. Projections made using the GOL model therefore have the property that world supply always equals world demand for each commodity. This property holds even if some countries impose limits on their exports or imports.

The GOL model has been used to provide projections of world food supply and demand to the year 2000 under alternative world economic assumptions.

Reflections on ERS experience

In addition to the technical concerns that stem from the specification and estimation of commodity sector models, there are a number of critically important administrative or organizational issues that can spell success or failure for activities of this type. These issues tend not to be mutually

FIGURE 8.3 WORLD GRAIN, OILSEEDS AND LIVESTOCK (GOL) MODEL SUMMARY

			GOL Country/Region																											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Row	
GOL Commodity			US	CN	EC	WE	JP	AZ	SF	EE	SV	CH	MX	CA	BZ	AR	VE	LA	AF	EG	ME	ND	OS	DO	TH	SA	EA	OA	RW	Sum	#RW
1	Beef and veal	BF	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	15	12
2	Pork	PK	1	1	1	1	1	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	12	15
3	Mutton and lamb	ML	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	14	13
4	Poultry, meat	PM	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	14	13
5	Poultry, eggs	PE	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	13	14
6	Wheat	WH	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	24	3
7	Corn	CN	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	0	1	1	1	0	1	20	7
8	Other coarse grains	CG	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	0	1	0	1	1	0	0	0	0	1	0	1	16	11
9	Rice	RI	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	22	5
10	Soybeans	SB	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	14	13
11	Other oilseeds	OS	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	1	0	1	1	1	1	0	1	0	0	1	18	9
12	Soymeal	SM	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	1	0	0	0	1	1	0	0	1	16	11
13	Soyoil	SO	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	19	8
14	Other meals	OM	1	1	1	1	1	0	0	1	1	1	1	0	1	1	0	1	1	0	1	1	1	1	0	1	0	0	1	19	8
15	Other oils	OO	1	1	1	0	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	0	1	1	0	1	20	7
16	Dairy, butter	DB	1	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	9	18
17	Dairy, cheese	DC	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	13	14
18	Dairy, other products	DO	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	14	13
19	Cotton	CT	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	22	5
20	Sugar	SU	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	25	2
	Column sum		20	15	20	19	19	12	6	20	20	13	15	8	17	14	9	10	10	6	14	11	7	7	5	9	11	2	20	339	

Notes:
1 = equations exist
0 = equations do not exist
RW = number of countries reported in rest-of-world for each GOL commodity

GOL = Countries/regions:

Developed (DC)

US	United States
CN	Canada
EC	European Community (10)
WE	Other Western Europe
JP	Japan
AZ	Australia and New Zealand
SF	South Africa

Centrally planned (CP)

EE	Eastern Europe
SV	Soviet Union
CH	China (People's Republic)

Latin America (LA)

MX	Mexico
CA	Central America and Caribbean
BZ	Brazil
AR	Argentina
VE	Venezuela
LA	Other South America

Subsaharan Africa and Middle East (ME)

AF	Africa (Subsaharan)
EG	Egypt
ME	Middle East and North Africa

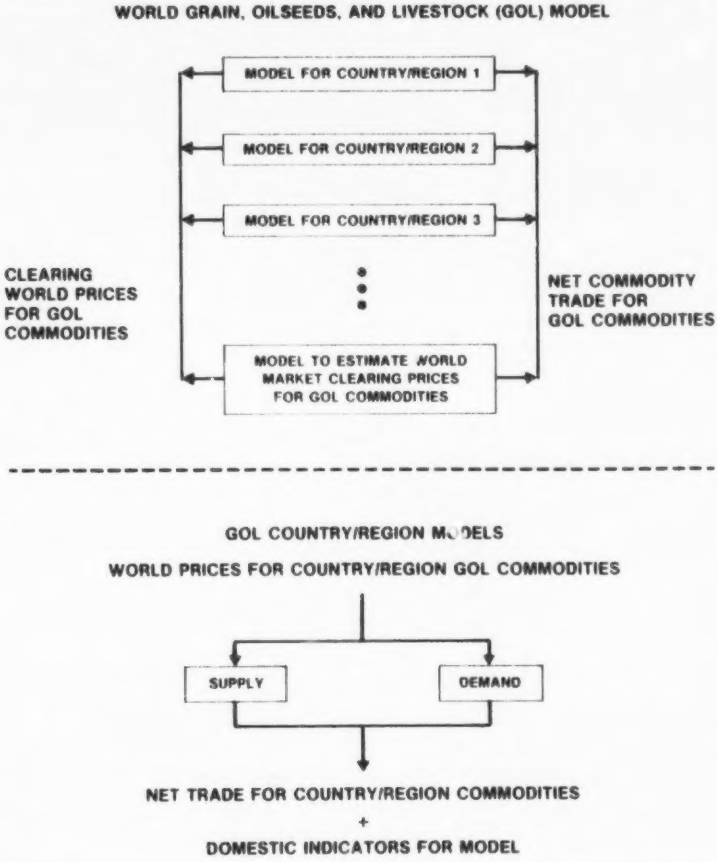
Asia (AS)

ND	India
OS	Other South Asia
DO	Indonesia
TH	Thailand
SA	Other Southeast Asia
EA	East Asia
OA	Other Asia

World (WD)

RW	Rest-of-world

FIGURE 8.4 GOL MODEL STRUCTURE


WORLD GRAIN, OILSEEDS, AND LIVESTOCK (GOL) MODEL
MODEL FOR COUNTRY/REGION 1
MODEL FOR COUNTRY/REGION 2
MODEL FOR COUNTRY/REGION 3
CLEARING WORLD PRICES FOR GOL COMMODITIES
NET COMMODITY TRADE FOR GOL COMMODITIES
MODEL TO ESTIMATE WORLD MARKET CLEARING PRICES FOR GOL COMMODITIES
GOL COUNTRY/REGION MODELS
WORLD PRICES FOR COUNTRY/REGION GOL COMMODITIES
SUPPLY
DEMAND
NET TRADE FOR COUNTRY/REGION COMMODITIES
+
DOMESTIC INDICATORS FOR MODEL

exclusive but are separately identified for purposes of discussion. They basically involve:

— the design and development of models;
— model maintenance and institutionalization; and
— considerations in model applications.

Design and development

The early phases of model development are obviously critical to long-run success and payoff. Why the model is to be built must be clearly established, including the scope of coverage for a model, the types of analyses to be handled and so forth. For ERS, a partial listing of the analytical agenda includes:

- — explicit evaluation of agricultural policy variables in behavioral and simulation contexts;
- — quarterly forecasting, especially commodity and farm aggregates, for 1 to 8 quarters ahead;
- — intermediate forecasting and policy analysis, annually for up to 10 years, to cover commodity, farm, aggregate, and macroeconomic variables;
- — projections of alternative long-run futures, resource requirements, food balances, and so forth, extending 40, 50 or more years;
- — tracing agricultural, food industry, and general economy linkages;
- — examination of spatial and other distributive impacts of technology, economic forces, and policy alternatives;
- — consideration of natural resource and environmental policies, particularly their implications for national and regional productive capacity; and
- — evaluation of economic forces affecting international commodity markets and the pattern of trade.

As can be seen, the agenda is a broad one. It immediately brings into question several matters regarding model design and development. For one thing, there is a question of how many models should be developed, that is, whether a single, multipurpose model can meet all needs. The ERS response has been no. The analytical needs have seemingly been distinct enough and the organization large enough to permit specialization of models and modelers. It has also been felt that different types of models offer various analytical advantages that should be exploited if at all possible. Moreover, the record at ERS and elsewhere on the construction and maintenance of comprehensive, all-purpose models, in all fairness, has been somewhat spotty. And casual observation suggests that diversification in modeling has quite often been cost effective.

However, there still remains the issue of commonality. Should there or can there be some degree of commonality across a chosen set of models? ERS has not fully resolved this issue. It has been observed that, if cross-commodity agricultural impacts are common to policy analyses, forecasting, and projections, it might make sense for there to be a common, core U.S. model within otherwise separate modeling systems. The rationale for this is that it would minimize model development costs while promoting the consistency of analyses performed using more than one model. Although this concern can be dealt with at least partially by the use of a common database, it really goes beyond the data input. It has been suggested, for example, that the annual FAPSIM econometric model could form the core of a long-run projections system as well as for a world agricultural model. The arguments for and against for such an approach have been advanced; still, the issue of commonality in a family of agricultural policy models remains.

Another basic issue in model design and development revolves around the question of simplicity versus complexity in models. To some extent, this involves the well-known debate over structure as opposed to forecasting in model design. But it also relates more generally to the intended scope of applications for a model. Proponents of complex models argue that as much of reality should be captured as possible. Opponents are quick to point out that it becomes extremely difficult with all that detail to sort out cause and effect, especially if results turn out to be counterintuitive and need to be traced back through the modeling system. ERS has followed a somewhat middle ground on this issue. The principal agricultural sector models at ERS, namely, FAPSIM, USMP, Quarterly Model, and GOL, tend toward the complex. However, in the case of the USMP mathematical programming model, for example, needless complexity and detail have been avoided. Similarly, the Quarterly Model has been designed to fit within the existing situation and outlook program and to feed results into other analytical systems. The GOL model, because of the broad commodity and country coverage required, has evolved a rather simplifed structure within countries. As an aside, it is interesting to note that the GOL model seems to suggest a principle of agricultural sector modeling: at a certain point, the overall scope of a model begins to limit the extent of detail that can be accommodated in any one of its components. The reasons for this seem to be ease of computation and interpretation.

Also affecting the degree of complexity are the conditions under which the model will be utilized. That is, particularly where short-term research and staff analysis are involved, timeliness of model application may be important. Large, complex models typically require substantial computer capacity, and rapid computer access to be useful in certain quick turnaround applications. Model design itself may be tempered depending on timeliness considerations. The ERS response to this issue is discussed below in the discussion of its applications.

In designing and developing an agricultural sector model, it is not enough to think in terms of the initial estimation alone. If such a model is to find use over time, it will have to be updated periodically. This calls into importance the database that is used to develop the model. Generally, the more elaborate or complex the model, the greater the demand for data. With a readily available database, this need not be a constraint. However, if a database must be maintained and if resource limits exist, the complexity of the model being developed may be affected. Data have not really been a limit at ERS. ERS has approached this concern in two ways. First, for some large modeling efforts, sufficient statistical assistant support has been provided to establish the necessary databases; this is the case for FAPSIM. Second, model developers have linked their models to existing databases. The USMP model system includes appropriate computer software to tap existing ERS data while the GOL model is based on a database contributed by the foreign agricultural service and the USDA.

A similar consideration involves the software available to estimate a model, to run simulations and to perform other computer operations. The advent of more powerful computers and more sophisticated software has done much to permit greater complexity in models and flexibility in their application. Software support has been adequate for model development at ERS. Original computer programming of the Gauss-Seidel solution algorithm was done at ERS during the 1970s. This continues to provide the basis for applications of the FAPSIM and Quarterly Model systems. The GOL model utilizes the TROLL software solution package, which is available commerically. And the USMP model relies on a solution algorithm developed at Purdue University, although a new, user-friendly software package developed at the World Bank is also being used on a trial basis.

A question of particular interest to program managers is, What ought to be the resource commitment to a modeling activity? ERS has experience in both large-scale and more modest efforts. There can be a payoff under either approach. The difficulty with large-scale modeling activities is that they sometimes try to do too much and fail to focus on the real purpose of the modeling exercise, which is to build an operational model. The difficulty with a more modest approach is that, if too limited an allocation of resources is made, it may preclude satisfactory results. In either case, it is most important that the economists involved in model development be given the freedom to work on the model with a minimum of distractions. This is important to model development as well as the building of human capital.

In ERS, we have tended in recent years to keep our modeling teams small. Groups of economists and statistical support numbering from two to four have been the rule for the Quarterly Model, FAPSIM, USMP, and GOL. This seems to have worked quite well in keeping the modeling activities focused and on track. We have also endeavored to minimize the interference with ERS modeling teams as they have gone about their developmental work. What is less clear, now that the models have been developed, is the appropriate resource commitment for model maintenance and application. Particularly, when a model has gained acceptance and is sought out for various applications, it does appear that additional resources must be added. ERS has strengthened its personnel commitment to FAPSIM. As demands on the other models grow, similar resource supplements can be expected to occur.

The final question on model design and development is, What model or combination of models is appropriate? For ERS, there has been a modeling strategy. With regard to domestic U.S. agriculture, a family of policy models was sought. Included are the annual FAPSIM model, which can be used for intermediate policy and baseline analyses; the USMP mathematical programming model, which is useful for exploring the spatial implications of alternative policies as well as providing greater supply-side detail; and a U.S. input/output model, which provides an important interindustry perspective. Many policy analyses involve short-term market outlook; in order to support the outlook program itself, it was also decided that a Quarterly Model for forecasting supply, demand, and prices of major commodities would be useful. On the international side, ERS has pursued two principal modeling lines: the IIASA system and the updated version of the grains, oilseeds and livestock (GOL) model. Finally, ERS has for several years participated in the development and application of the Iowa State CARD model for natural resource analyses.

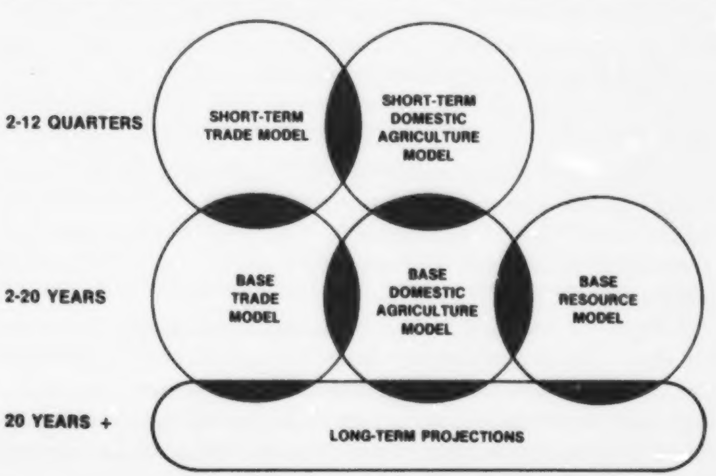
Maintenance and institutionalization

Having developed a model, the sometimes less glamorous task of keeping it updated and available for use over time must be addressed. In part, this is an organizational problem, but it is also a people problem.

Certainly one of the greatest problems that has faced ERS in its use of models over the years has been the failure to adequately institutionalize them. A number of models have been developed only to fall into disrepair and disuse because of poor documentation and staff turnover. ERS is currently attempting to address this problem by recognizing that ERS has a continuing interest in the proper institutionalization of certain models. An ad hoc models steering committee has been established to lay out an appropriate course of action. In getting started, major ERS program areas have been identified and described for which an economic model or model system is necessary to achieve consistency, timeliness and an analytical basis for program output. Based on this assessment, a limited number of "agency" models are to be identified. These models are to be central to the ERS program of economic research, analysis and market outlook. Once identified, the models will be institutionalized within the organization. ERS is hoping to avoid the all too typical experience where a model is so highly personalized that the model can no longer be used when the model builder changes positions, because others do not understand it or do not feel comfortable with its structure. Each "agency" model is to be established as a component of the ERS organization with an identified leader who assumes responsibility for all model development, maintenance, documentation and applications.

In considering model coverage to meet ERS analytical needs, thought is also being given to what that coverage ought to include. The schematic in Figure 8.5 is one attempt to define this coverage. This diagram reflects the overlap that obviously must exist with one or more "agency" models. Such overlap is both desirable and necessary to assure a consistent and rigorous treatment of issues that span subject areas. When more than one "agency" model is involved, it raises the possibility of linking models and of sharing a common core of related ideas, as mentioned earlier. "Agency" models need to be relevant and applicable to a broad range of issues, which suggests that they should be viewed as tools used in analysis and not necessarily as the end product. Thus, to a certain extent, these models can be expected to develop in response to demands placed on them. The ERS organizational structure needs to accommodate this, allowing some flexibility in resource allocations over time to permit further model development.

FIGURE 8.5 AGENCY MODEL STRUCTURE


2-12 QUARTERS
SHORT-TERM TRADE MODEL
SHORT-TERM DOMESTIC AGRICULTURE MODEL
2-20 YEARS
BASE TRADE MODEL
BASE DOMESTIC AGRICULTURE MODEL
BASE RESOURCE MODEL
20 YEARS +
LONG-TERM PROJECTIONS

Exactly how ERS will achieve the institutionalization of its larger, "agency" models is still unfolding. Quite obviously, there are a number of candidate models for "agency" status among those that already exist. In any event, two steps will be taken to promote institutionalization. First, each of the "agency" models will have a clear statement of purpose and justification. The justification statement will relate to the mission and responsibilities of ERS and to the need for a particular type of analytical support. The statement will also indicate how the model is related to other "agency" models; it will identify the major users of the model; and it will describe how the output of the model will be used. Second, each "agency" model will be fully documented with at least one staff report which gives an overview of the model, describes the model structure, estimation procedures and solution package, and provides a detailed listing of equations and coefficients used in the model. This documentation will be revised periodically as the model is updated and modified.

Another major concern relating to model maintenance involves the associated database. This is touched on earlier in the paper. With complex models that depend on large amounts of data, a parallel database development and maintenance activity is imperative. At ERS, we have typically managed large data files through a system called T-DAM. These files have been stored as a group on the mainframe computer, but updating has been the responsibility of individual file holders. This has worked acceptably, although the multiple uses that one would hope for in the use of data have not always been realized. ERS is currently working on a new agency database called ARIES, with common naming conventions and associated software for updating, retrieval and display. It is expected that, among other things, this common database will facilitate model development and maintenance, while reducing or spreading the burden of updating the database itself.

Applications of models

If a model is to become something other than an academic exercise, it must be applied. Within ERS, this means that a model should be useful and used in situation and outlook, policy analyses, and projections activities. Achieving this will depend on selecting the right staff, application and end users.

To begin, one must have the appropriate staff in place to apply the model and assist in the interpretation of its results. This can be a problem. In certain cases, the specialized skills of the model builder may not be the same as those of the experts in the subject matter who deal with applied problems. This is not a negative reflection on model builders; rather, it is a recognition that some analysts or policy researchers have a grasp of their subject matter that goes beyond what can reasonably be expected of the model builder. The converse of this situation can be a problem, too. Those who do not build the models may not understand them sufficiently or may not be willing to invest the time required to learn to apply them. Therein lies a dilemma: how to best bring together the specialized skills and knowledge of those who build models with those who lead research and analysis in particular subject areas. In a large organization like ERS, the division of labor to focus on specialized tasks promotes the development of agricultural sector models but can complicate their application.

In ERS, the application of ecnomic models tends to occur in three ways. First, in a great many instances, the full agricultural sector models are run to perform various analyses. To facilitate this type of analysis, the FAPSIM, USMP, and GOL models have been installed on an ERS minicomputer (IBM 4331). A second form of analysis is based on the use of components from the sector models. The commodity subsector models for corn, wheat, hogs, and so forth have been made available to analysts for use on personal computers. Components from both FAPSIM and the Quarterly Model are used in this manner. The final form of model application actually involves use of multipliers and elasticities from the sector models. For many short-term projects, there is neither the time for the need to run a full-sector model. In these cases, analysts rely on previously estimated parameters from the sector models.

The application of models ultimately involves the end users of the information generated. In some instances, these users will request a model printout, although this is not usually the case. Even when they do, there is considerable risk of misinterpretation. This can leave the end user dissatisfied and may possibly limit future requests for assistance. As a general rule, analysts in ERS try to provide interpreted results via memos, staff reports or research manuscripts. This follows from the notion that the models are tools for analysts that often require human judgment not only in their application but in their interpretation. Another consideration is the massive amount of information that typically is generated by agricultural sector models. Finding some way to summarize and appropriately cast the information available is a difficult problem. ERS has been looking at ways to better organize model output so that the trade-offs relevant to policy makers can be highlighted.

Conclusion

In a world that grows ever more complex, it is important that public and private decisions affecting U.S. agriculture be carefully considered. This suggests a role for agricultural sector models that can capture the essential economic structure of agriculture in a manner that is useful for purposes of research, analysis and forecasting. The Economic Research Service at the U.S. Department of Agriculture has developed several such models. Four principal models at ERS include: the FAPSIM intermediate-term policy and forecasting model; the Quarterly Model for forecasting the next 3 to 6 quarters; the USMP model for spatial and supply-side analyses; and the GOL model for international agricultural forecasting.

Given the ERS experience with agricultural sector models, a number of reflections are possible. These tend to fall into the categories of design and development, maintenance and institutionalization, and model applications. General issues include size and scope of models, specialization of researchers in model development versus applications, institutionalization of models to ensure continuity and consistency in research and analysis, and working with the end users of the model results.

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9

A Critique of Existing Models for Policy Analysis

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*Stanley R. Johnson**

Introduction

Each of the models previously reviewed has important and, to date, unexploited potential for agricultural policy analysis. Present applications of these models are based on rich backgrounds in theory and in empirical analysis suggesting important qualitative and quantitative information on key structural parameters. Yet, even with the extensive investment in modeling technology and the development of economic models for applied policy problems, there is a surprising lack of direct input from quantitative policy models in routine regulatory decisions for commodity markets and the agricultural sector (Hendry, 1980; Johnson, 1981; Klein, 1981; Lucas, 1976; Rausser and Just, 1981). Why are quantitative models incorporating policy decision frameworks not utilized more intensively and extensively in the design and evaluation of commodity market and agricultural sector policies?

The purpose of the present critique is to identify limitations of existing economic models for agricultural policy analysis and to suggest some alternatives. The critique is not intended to be negative. The limitations of existing models, once identified, are accompanied by recommendations for improvements. Most of the limitations of agricultural policy models derive not from the models themselves but from the way in which they are developed and the methods employed in specializing the models to particular policy problems. A major thesis of the paper is that many of the difficulties experienced in applying quantitative models to policy follow from the fact that those who develop and apply these models are frequently too separated from the policy arena. As a result, the models are not specialized appropriately and the outputs are not useful to those responsible for policy actions. Finally, the organizations in which these models are developed and specialized to particular policy problems place important restrictions on perceptions of the policy problems and their analysis.

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The conclusions drawn from the critique contain good news and bad news for those associated with quantitative policy modeling and also for policy makers who intend to utilize more fully these information sources in design and evaluation exercises. The good news is that the theoretical foundations for the policy models have evolved impressively in recent years. In addition, the experience base for applying these models has deepened as a result of numerous applications (see, for example, Johnson, Huff and Rausser, 1982; Ray and Richardson, 1978; Schuh, 1981; Thompson, 1981; U.S. General Accounting Office, 1977). The result is that applied economic models now can be constructed less expensively and with specialization to particular policy problems. Not insignificantly, the pool of professionals capable of working with these models has increased to the point that quantitative policy modeling activities can be contemplated without assuming high training costs or excessive start-up times.

The bad news involves the organizations in which policy analysis units are typically contained, the way policy analysis results are presented and, most importantly, the changing dimensions of agricultural and commodity policy problems. For the first, the quantitative modeling personnel are usually segregated in agricultural ministries or departments. This compartmentalization has resulted in models with policy performance measures that are defined quite narrowly. Generally, the policy performance measures relate almost exclusively to the agricultural sector or to specific commodity markets (Anderson, 1974; Bowers, 1981; Tweeten, 1981).

Second, the presentation of quantitative policy modeling results is, in general, unbelievably bad. Decision makers are frequently given model outcomes in forms difficult to assess and without appropriate information on how the results are generated. As a consequence, the results are not used. Decision makers simply will not use policy analyses developed with constructs that cannot be communicated effectively. The decision makers must understand, at least intuitively, the nature of the analysis generating the results; the models must be transparent. In addition, policy analyses must be timely. All too often, quantitative policy analyses have not been generated because it has not been possible to solve models on a turnaround basis consistent with the timing for decisions.

Third, political realities in most developed countries suggest that policies designed specifically for agriculture will be increasingly unpopular. Few people in these developed economies have an identification with agriculture. Thus, agricultural commodity and sector policy initiatives must be more broadly conceived if they are to be successful. These aspects of policy formation and analysis are complicated by the evolution of policy-making processes with the increasing importance of organizational and political dimensions for policy process outcomes.

Highlights of presentations on alternative models

This workshop has provided a review and evaluation of six different quantitative policy models. These include:

- an annual econometric model for Canadian agriculture;
- an international, multi-country systems model;
- an input-output model for Canada;
- a regional agricultural model for Canada;
- an annual macroeconometric model for Canada; and
- a model of linkages between agriculture and the Canadian macroeconomy.

Comments on these models are based largely on information available prior to the workshop. However, they have benefited from presentations on these models at the workshop and, in some cases, draft copies of the papers.

Annual econometric model for Canadian agriculture, by Robertson and Krakar

The annual econometric model of the Canadian agricultural sector has commodity markets as basic components. That is, the annual econometric model provides a representation of the price determination processes for major agricultural commodities in Canada. These commodity market models are linked on both the supply and demand sides. A simplified farm income component is included as well. This farm income component is employed to relate commodity market prices and farm production to the performance of agriculture.

The structure follows contemporary approaches for agricultural commodity models. On the supply side for crops, acreages and yields are modeled. The supplies of livestock commodities incorporate physiological restrictions. Farm and retail prices are determined on the basis of retail demand specifications for each commodity and aggregated representations of processing sectors. Government commodity programs are included both implicity and explicitly. For wheat and barley, Canadian Wheat Board and off-board prices are modeled along with farm and commercial stocks. For livestock, effects of stabilization policies are modeled implicitly. That is, the specifications in these components of the model are not sufficient to permit direct analyses of impacts of stabilization policy instruments.

Advantages of the model specification follow from the experience with the quarterly Food and Agriculture Regional Model (FARM) system. Many specifications of individual equations are similar to those in FARM and have benefited from its use in applied policy work. In addition, the grains components provide useful structures for linking domestic markets to those dominated by U.S. agriculture. Limitations of the model related to linkages across commodities (both in supply and demand), the correspondences between farm income and government policy instruments, linkages to the other sectors of the economy and, finally, the limited potential of the model for investigating commodity and stabilization policies.

Policies that can be addressed are largely for crops. However, how the model formally incorporates endogenous policies and reflects exogenous effects for their sensitivity to policy instruments is not clear. The model is designed for policy analysis but, unfortunately, has a structure more oriented to forecasting. The model is large (approximately 600 equations) and not strongly restricted by theory. For this reason, it will be difficult to communicate to policy makers and to focus on specific policy problems. The theoretical content of policy models is critical to their capacity for policy analysis.

An international, multi-country systems model, by Frohberg and Fischer

This model is the outcome of a substantial international undertaking conducted at the International Institute of Applied Systems Analysis. The general structure for the model is apparently determined by the policy questions to be addressed. These include trade policies, economic growth, stabilization and other factors affecting the international price equilibria in agricultural commodity markets (Frohberg et al., 1978). Components of this model were contributed by participating countries. The development of these components reflects the level of support of the participating nations. Only recently have solutions to the general model across countries been undertaken. These solutions require substantial computer capacity and fortuitous selections of initial conditions.

Information on the experience with the IIASA model in policy analysis is not well disseminated. This is perhaps because of the long gestation period that has been required for development of the IIASA model. In addition, the modelers at IIASA are removed from policy makers and the policy arena. For this reason, the modelers have perhaps not felt the pressures that those in governmental agencies experience for the development of policy models that can perform effectively and within relatively short time frames. This lack of attention to a specific policy focus may be a major limitation of the IIASA model. Without a policy orientation, support for this modeling activity and, in fact, the model itself, may suffer. Policy models must be directed to users of policy information.

One important structural question for the IIASA model involves price determination. For Canada, the demand functions for agricultural commodities are driven largely by per capita income. Demand systems have been applied in the country components that, because of separability, do not permit important price substitutions to occur. Thus, the solutions to the model are more highly conditioned by income than by relative prices. But models of international price determination processes must reflect impacts of changed relative prices on consumption and production patterns. Other questions about the model concern price expectations, the capacity to study stability when uncertainty is not reflected in the supply response and consumption specifications, the capacity to incorporate policy changes and the robustness of the basic parameter estimates.

These questions should not be taken as an indictment of the IIASA model. It is an experimental model and it represents a first attempt to reflect directly and in detail the effects of internal commodity and agricultural sector policies of specific countries in an international price equilibrium for agricultural commodity markets. The normative optimizing approach employed in solving the model is intriguing, as is the objective of integrating model components developed frequently with different theoretical constructs from the cooperating countries. If the results of the policy experiments with the IIASA model can be communicated effectively, much will be learned about workable approaches to incorporating endogenous variables for trade within agricultural and commodity models.

The Canadian input-output model, by Syed

The agricultural sector of the Canadian input-output model is developed from survey data. From these, it is difficult to classify farms by type. For this reason, agriculture has been treated as one industry in the Canadian input-output table. This feature of the input-output table seriously limits the potential that it has for evaluating interindustry effects of agricultural policies. A similar approach is used for the provincial models with agriculture again as one sector. This aspect of the provincial models may not be as limiting for agricultural policy analysis as that in the case of the national model, given that specialization in agricultural production exists within the provinces.

If the Canadian input-output models are to be more useful for evaluating impacts of agricultural policy and for evaluating impacts of policies in other industries on agrilculture, it will be necessary to disaggregate agriculture. The information required to perform this disaggregation can be readily developed using budget data. That is, farm budget data can be employed to incorporate in the input-output model production requirements for different agricultural commodities. These commodities can then be treated as "industries" in the input-output model. By utilizing budget information (already available in the provinces) and by calibrating the basic input-output model to reconcile the totals developed for agriculture from the survey, the value of the input-output model can be enhanced for agricultural policy analysis.

Input-output models are useful in analyzing impacts of technology, regulation and other factors that affect agriculture and kindred sectors of the economy. Impacts of policy changes are frequently evaluated with input-output models by changing structural coefficients and input and final demands. With the changed coefficients and/or exogenous factors, the input-output models are simulated to permit comparisons for technology, regulation and other changes. A particular advantage of the input-output models for agricultural policy analysis is their potential for developing estimates of policy outcomes across industries. As the introductory comments of this paper indicate, these linkages are likely to become increasingly important in evaluating and designing agricultural and commodity market policies.

Limitations of policy evaluations with input-output models involve the implicit production functions. These approximate production functions are not likely to be good for drastic changes in production processes, for example, for agricultural production technology changes or for changes in relative prices. For this reason, it is necessary to carefully apply input-output models in evaluating policy alternatives. Still, the input-output models hold the possibility for viewing agricultural policy outcomes more broadly, in terms of impacts on other industries and national aggregates.

A regional agricultural model for Canada, by Klein and Graham

The regional agricultural model is similar in structure to those of CARD at Iowa State University (Heady and Egbert, 1969) and subsequent variations (McCarl, 1982; Walker and Dillon, 1976). These models include price determination mechanisms for major agricultural commodities. However, they have considerably more detailed representations of supply response than econometric models of the agriculture sector oriented toward commodity markets. Generally, the models are specified to represent resource capacities, production technologies and particular regions utilizing representative firms. Solutions to these models provide not only market prices but also resource utilization patterns that follow from the price and production levels. Generally, the production decisions of microeconomic units within regions are fully characterized. This detail in modeling does not usually carry over to consumption and especially to final demands for agricultural commodities. The important linkages with consumption are largely for feedgrain by the livestock sector.

The kinds of government programs these models can address require specialized information on production processes and choices of farm decision makers. These include regional development policies, conservation, input regulations, transport policies and others. The model is normative and this feature, to an extent, makes it feasible to more easily incorporate policy options. However, linkages of behaviors of firms to market outcomes, expectations and other incentives that may be conditioned by policies are more difficult to reflect. Still, these regional models represent an important tool in the arsenal of economists for dealing with economic development problems. Interestingly, they also provide a basis, through the normative modeling of production, for evaluating effects of policies directed toward specific sectors of agriculture. There is a trend toward merging these models with the interindustry structures discussed previously to study impacts for other sectors of agricultural policy.

The Klein and Graham paper is more of a proposal or pilot study than a finished product. For this reason, it is difficult to critique. There are, however, two points that can be raised relative to the foregoing more general discussion of regional models. The first is the proposal to limit the choice processes of the representative firms. If this choice process is not more fully reflected in the model, it is not clear what economic content remains. The motivation in limiting the choice process of representative firms is to simplify the model. But perhaps using fewer regions is a more reasonable answer. The second observation concerns the policies for study. These seem appropriate to regional modeling and timely for Canada. However, to be of value, the technology and regulatory options will have to be traced carefully through the final consumption components of the model.

Macroeconomic models for Canada, by Selody and Rose

The review of the small annual model (SAM) by Selody and Rose has provided a valuable perspective for the discussion of agricultural policy models. A theme in the discussions of models to this point and, in fact, in the present paper is the increasing importance of the capacity to evaluate agricultural policies in terms of impacts not for agriculture as narrowly defined. Selody and Rose, in the process of reviewing the SAM model, which is similar in structure to many other macroeconometric policy models, have provided important insights on how agriculture might be introduced in economy-wide representations. Specifically, two approaches are indicated as possibilities for integrating agriculture into the macroeconometric model. The first, discussed in detail by Selody and Rose, involves adopting the view that the aggregate level of economic activity is determined by the macro structure. The role of agriculture in the model then is largely allocative. That is, the level of economic activity is determined within a "functionally" specified model. Then, allocations between industries can be studied by focusing on, for example, agriculture.

A second and more ambitious approach is to assume that there is a dichotomy between agriculture and nonagriculture in the macroeconomy. In this case, the level of economic activity is determined by the two sectors. This approach allows agriculture to be distinct from the rest of the economy but requires important structural information on feedback relationships between agriculture and the nonagricultural sectors. This second approach to the modeling of agriculture and evaluating impacts of the nonagricultural sector requires a considerably stronger information base than is available at present on feedback linkages.

The review then suggest not two but three options. The first and simplest is the one now employed, at least implicity, in most agricultural modeling efforts. The agricultural sector is viewed as operating on a satellite basis to the remainder of the econmy. The second approach is more ambitious. This approach allows agriculture into the macroeconomy, but only on an allocative basis. This "disaggregation" of macroeconometric models can be achieved relatively easily. Obviously, the most potentially informative approach to studying agricultural impacts on the macroeconomy and the reverse involves "splitting" the macro models into agricultural and nonagricultural sectors. While this approach is possible in principle, agricultural models that are much more highly aggregated and similarly aggregated versions of macro models will be required if these efforts are to be successful. The most extensive work in this area is by Penson and Hughes (1977) who utilize only crops and livestock commodities in the agricultural sector.

Linkages between agriculture and the macroeconomy, by Romain

The study of linkages between agriculture and the macroeconomy has experienced much recent attention (Gardner, 1981a; Johnson, 1977; Penson, 1981; Penson and Hughes, 1977; Tweeten, 1980). Traditionally, these linkages have involved accounting relationships and satellite models. That is, the agricultural sector has been viewed as small relative to the rest of the economy and, when agriculture is included in macromodels, simple linkages achieved by disaggregating the national accounts is utilized. In fact, this is the way agriculture is currently represented in most of the large-scale macroecononometric models of Canada, if they isolate agriculture at all. Similarly, in agricultural sector models, prices from the general economy are taken as exogenous, and there are no behavioral relationships permitting feedbacks between the nonagricultural economy and agriculture.

This rigid approach to modeling agriculture has come under increasing question (Gardner, 1981b; Tweeten, 1981). These questions have two themes. First, it has become apparent that tax policies, interest rates, and other variables are critically important in influencing agricultural production decisions and the agricultural balance sheet. Thus, models like the one by Romain have attempted to model more fully the production, investment and consumption decisions within agriculture and their interactions with the remainder of the economy. The spirit of these models has been to identify production, consumption, investment and savings behaviors within agriculture, to condition them on the basis of selected policy instruments through price impacts, and then to provide standard sectoral linkages for the national aggregates. This modeling work is in early stages, but has shown how interest rates and tax policies affect production, consumption, savings and investment within agriculture (Penson, 1981; Penson and Hughes, 1977).

A second theme in the development of the "sector-to-sector" models concerns price formation, monetary policy and inflation. It is clear that tight monetary policies have impacts on prices. Moreover, if there are price rigidities in other sectors, these impacts tend to be concentrated in sectors where prices are determined by market conditions and are flexible. This thesis has spawned a number of recent studies highlighting effects of monetary policies on agricultural prices and linkages between agricultural prices and prices of other primary commodities to the general price level. Much remains to be learned about the nature of these linkages. However, there is increasing empirical evidence of causal relationships between the general price level, monetary policy, agricultural prices, exchange rates and the monetary aggregates.

Policy problems that can be addressed in these expanded sector-to-sector models are different from those discussed previously. Of course, price determination in agricultural commodity markets can be analyzed. However, most of these agriculture-macroeconomy models have few sectors, and detailed implications of the price determination process are not modeled. Three important policy issues for these models are:

- effects of agricultural policies on national level performance for variables;
- impacts of policies for the economy at large, consumption, investment and taxation on agriculture; and
- relationships of agricultural price and general price movements and impacts of monetary policy.

The model presented by Romain is an extension of the work of Penson and Hughes (1977) and is of the sector-to-sector type. The theme emphasized in the model relates to interrelationships between the agricultural and non-agricultural sectors. The difference between this model and the forerunner by Penson and Hughes is in the disaggregation of the agricultural sector. In the model proposed by Romain, agriculture is disaggregated by major crop and livestock commodities whereas, in the Penson and Hughes model, only crops and livestock are considered. Disaggregation comes at the cost of increasing substantially the size of the model, and this seems to involve a questionable judgment. Specifically, are we as economists sufficiently well advanced in understanding intersectoral relationships that we should begin to undertake extensive modeling exercises of the type Romain has proposed? Or should we restrict our attention to grosser approximations of the agricultural sector in such endeavors? The latter would seem the more appropriate, based on the empirical results that are available to date.

In addition to this decision regarding the size and scope of the agricultural sector as incorporated in the model, there are other aspects of this model that are deserving of comment. First, the price expectations are handled using a concept oriented toward futures markets. In view of the literature on rational expectations, this approach could be improved. In addition, in the livestock equations, it appears that the use of physiological relationships constraining the model would be helpful in developing more realistic dynamics. Finally, there is the question of the microeconomic foundations of this and the foregoing models. Tax policies and other policies distort distributions of prices that are faced by agricultural and other decision makers. Unfortunately, however, the risk-based microeconomic foundations relating supply response and demand to these distortions and distributions are relatively limited (Choi, Johnson and Menezes, 1983; Newbery and Stiglitz, 1981). Despite these limitations, the approach holds great potential for developing the kind of information that will be increasingly necessary for supporting policy in the changing political environment for agriculture.

Summary and "laundry list"

The six modeling approaches evidenced in the papers reviewed all exhibit advantages and disadvantages for different policy questions. It is unlikely that an all-encompassing agricultural policy model will be developed. Instead, different models will exist that can focus on specific aspects of agricultural policy questions, much as is the case currently. Economic models are best viewed as specialized approximations of the economic system that are appropriate for certain dimensions of policy questions. It will be increasingly imporant as modeling technology develops to identify specifically the policy problems that can be handled by the different types of models and the strengths and weaknesses of these models for timely policy analysis. Much of the present confusion about the quantitative economic models and policy design and evaluation is related to the excessive claims for the models and to a failure to delineate carefully the policy problems for which the models are intended. Frequently, this is because the policy evaluation units have "put all of their eggs in one basket" and feel compelled, therefore, to present their model as the one that can solve all the policy problems for agriculture.

Finally, to the "laundry list." In reviewing these models, a number of suggestions for improvement both in economic content and for policy purposes have been advanced. The present discussion summarizes these points along with brief comments. Each represents what, on the basis of the reviews of these models, would appear a fertile area for research on improved model specification in policy applications of existing models.

— Micro foundations: Large-scale agricultural models have been used largely for economic forecasting. As these models begin to be used more intimately in policy analysis, their structural integrity will increase in importance. Attention to structural integrity will ultimately result in improved micro foundations for the aggregate relationships in the models. The truth of the matter is that modern economic theory contains results that should be better incorporated in these models. These results can help to develop correspondences between the rationales for model specifications at the firm or representative firm level and at the market level. At present, with attempts to model risk in decision making, there is a relatively weak theoretical basis for aggregate specifications. The weak theoretical basis is no doubt responsible for unfortunate experiences in applying these models to policy stabilization problems.

— Time series versus structural modeling: There is much to be learned from time series analysis for the development of structural models, econometric or constructed, for policy analysis. The results of time series analysis show that predictive content is really not a serious problem for modeling. By merging time series and structural approaches, the modeling question becomes the decomposition of observed variation in the variables endogenous to the modeling system. Generally, the preferred situations are those in which the economic rationale offered contributes more to explaining the total variation in the observed endogenous variables. However, merger of the econometric and time series approaches makes it possible to utilize structural models that rely less heavily on curve fitting and ad hocery (Leamer, 1978). Also, this merger produces models that can more realistically represent the forecasting ability of the economic constructs in the available historical data.

— Expectations: A host of approaches have been taken to modeling expectations in the six models reviewed. Expectations are, in fact, implicitly or explicitly an important part of most commodity market and regional models. This is because we are attempting to anticipate the actions of decision makers with these models. Obviously then, properly reflecting the information base available to the decision makers and their formation of expectations is critical to the success of the model. Unfortunately, most of the present modeling approaches utilize backward-looking expectations. The rational expectations literature, however, suggests the opposite. That is, expectations should be forward-looking. Such forward-looking expectations hold the possibility for proving the content and policy usefulness of the models because they represent more realistic representations of the decision processes and, importantly, expectations that are consistent with the argument that has been advanced for the determination of the endogenous variables in the models.

— Physical restrictions: Particularly in livestock models, physical restrictions have been found to be an attractive way of conditioning supply response (Chavas and Johnson, 1982). Until recently, the supply response for livestock commodities was handled largely with long lags in input and output prices. These lags represented collinearity problems that were especially difficult for models estimated with relatively short time series.

The physiological conditioning of supply is an advantageous way around the multicollinearity problem by adding additional information. It has proven to be satisfactory for supply response modeling where production periods are not consistent with the model time frame, as for the annual models utilized in most policy analyses.

- Time and space aggregation: One of the major problems with existing policy models concerns time and space aggregation problems. The fact of the matter is that most policy models are too large. More aggregated versions of the models should be available, models of models if you will. This would improve the capacity to communicate about the models. In addition, it would make it possible to specialize the models more easily for particular policy problems. There is a great tendency to try to build models that are comprehensive. While comprehensive models, as in the case of IIASA, are useful, all models do not have to be that large. Higher aggregations in time and space can be useful in developing more operational policy models. These higher aggregations are supported by techniques merging time series and structural modeling methods.
- Endogenous policies: Policies are frequently taken as being endogenous to the models. This makes it difficult to utilize the models for policy design and policy evaluation. Considerably more attention should be directed to the incidence of particular policies in the time series data and to constructing models that, at least theoretically, incorporate policy effects. Approximate reduced forms that reflect implicitly policy measures are not of great use in adapting models for policy analysis. Economic structure is critical if the models are to be employed effectively in policy analysis.

To conclude, the themes of the laundry list and the general summary emphasize the importance of theoretical foundations for policy models. Perhaps the profession has become somewhat undisciplined during the development period for the short time frame forecasting models of the past 10 to 15 years. In these forecasting models, curve fitting and evolution from strong theoretical bases has been evidenced. As these forecasting models have been applied to policy, it has become painfully apparent that solid theoretical foundations and attention to policy instruments is essential if the models are to be of value. Much can be learned from the programming approaches implicit in the IIASA and regional models in this respect. The same is true for the input-output models. The new generation of applied economic policy models will undoubtedly rest on stronger theoretical foundations than those now being operated.

Policy setting for agriculture in the next decade

There are two aspects of the policy setting for agriculture in the next decade that have an important bearing for the critique of existing models for policy analysis. These are the likely economic and political settings. First, the economic setting includes broadened participation in world markets, increased interaction of agriculture with other sectors, and a changing structure within agriculture. Each of these economic aspects of the policy setting for the next decade must be viewed within the context of the general world economic situation. This general world economic situation, if it continues as projected, has far-reaching implications for agricultural policy. Secondly, the political dimensions of the policy setting for agriculture will be an increasing issue in the next decade. Politically, agriculture will have decreased power. Those involved in agriculture will be fewer in number. This political trend will be complicated by the fact that the agricultural legislative processes will become more fragmented and more influenced by special interest groups.

Economic setting

The Food and Agricultural Policy Research Institute at the University of Missouri and Iowa State University produces a multiyear forecast (Womack et al., 1984). A 10-year forecast for U.S. agriculture has just been completed. While not concentrating on the details of this forecast, selected comments on the economic setting for agricultural policy are implied in the results.

The institute forecasts are developed with a large-scale agricultural sector model for the U.S. economy. The forecasts integrate world production and consumption and, as well, incorporate a macroeconomic forecast developed by Wharton. The Wharton macroeconomic forecast drives the agricultural sector on a satellite basis. However, the present Wharton forecast is not substantially different from those of U.S. government agencies and other private firms selling information. The message in these forecasts is for a continued large deficit in the U.S., relatively high interest rates, a slightly weakening but still strong U.S. dollar, and growth in the U.S. economy and world economy that is stable but relatively slow.

The forecast assumptions include a U.S. agricultural policy similar to that in place for 1983-84, with a modest upward trend in technology in the U.S. and the rest of the world, slow domestic economic growth, and large government costs to hold agricultural prices at or near existing loan rates. This implies that the projected government costs over the 10-year period for wheat, corn and grain sorghum, rice, soybeans and cotton will be in the neighborhood of $10 billion to $12 billion annually.

The 10-year forecast emphasizes the overcapacity problem in agriculture. Little relief from this overcapacity problem is likely as incomes improve in the rest of the world. The stagnant demand situation for meat products and, in fact, wheat and the overcapacity in the U.S., together with increased output as a result of using available technologies in the rest of the world, suggest that it will be extremely difficult to shift loan rates from their 1983-84 levels. Thus, for agriculture, the policy situation is one in which substantial government costs will be incurred if farm incomes and, as importantly, land values are to be held even at their current rates.

In summary, the economic setting for world agriculture in the next decade is not bright. High government costs will be required to maintain existing U.S. loan rates and prices for major agricultural commodities. These loan rates are currently essentially the world price levels. The overcapacity situation, together with increased attention to government deficits, suggests potential important changes in the structure of agriculture. These changes in the structure of agriculture may be related to production shifts from marginal lands as capacity is reduced and competition is increased among suppliers to the work market. Likely outcomes are continued financial stress in agriculture, continued movement of the population out of agriculture, increases in farm size and increased specialization of agricultural production.

Political setting

The key feature of the political setting for agriculture in the next decade is the political power of agriculture related to other industry and interest groups (Downs, 1957; Fiorina et al., 1978; Jacobson, 1980; Kau et al., 1982; Krueger, 1974; Tufte, 1978; Welch, 1974). Clearly, the population in the U.S. and Canada associated with agriculture is small and decreasing. Agriculture can therefore be expected to have less political clout in future years. This situation is complicated by the fact that the traditional coalitions between agriculture as the supplier of food and urban legislators concerned with low-income populations and food assistance may, in fact, break down. Food prices are not likely to increase in the near future because of the overcapacity in agriculture and low farm prices. Thus, the urban representatives may not see it in their interest to develop affiliations with agriculture to ensure continued supplies of food at relatively low cost.

An additional aspect of the political setting that deserves attention is typified by the situation in the U.S. Senate and House agricultural committees (Arnold, 1979; Fenno, 1973). These committees have subcommittees that are commodity-oriented. This subcommittee organization fragments the policy-making process and makes it more feasible for special interest groups to influence policy. The result is that agricultural legislation is not comprehensive but is instead a collection of agricultural commodity policies. A recent quotation from a House staff person illustrates the point: "Agricultural committees spend all their time fiddling with loan rates and target prices and have completely lost perspective for agricultural policy in general." While this quotation may be an exaggeration, it does indicate a major problem. Where will the comprehensive agricultural legislation be developed?

In Canada, it is also becoming apparent that policy analyses to support agricultural programs and policies must not be justified in terms of agriculture alone. Even more importantly, policy and program analyses must not be developed for particular special-interest commodity groups. Instead, to participate effectively in the policy arena, it is necessary to view agriculture broadly. That is, policy and program analyses intended for both design and evaluation will be increasingly oriented toward showing impacts of agricultural programs and policies on the general economy and on other sectors. These kinds of demand on program and policy analysis models will change policy research and priorities on policy model development.

Finally, in discussing the political setting, it would be a gross oversight to not comment on international dimensions. Despite various interventions in international commodity markets, the world economy is becoming more integrated. The capital can move more freely between countries, countries can participate more fully in international markets, and "special relationships" between traders will become increasingly difficult to enforce in the projected excess supply situation. If competition in world markets increases, benefits to large traders like Canada and the U.S. may diminish. The increased production levels in developing economies and by traditional importers of agricultural products means that increased efficiencies will have to be achieved in Canada and the U.S. if their positions in world markets are to be maintained or expanded. These increased efficiencies will translate into low prices compared with existing loan rates.

Policy processes and policy outcomes

It is apparent to those familiar with policy formation and evaluation processes that more is involved than a choice based on clearly articulated goals and objectives. The processes by which the decisions are made themselves have important implications for policy outcomes. There are several ways of viewing the policy process using concepts of organizational behavior. Those utilized in the present context are from Allison (1971), Becker (1983), Brill (1979), Buchanan (1965), Downs (1957), Keeney and

Raiffa (1976), and others. Policy analyses are developed within organanizations and have important implications for their outcomes. The changing political and economic circumstances for agriculture and the changing structure of government in developed societies indicate that the development and analysis of policy should be viewed as important in determining the outcomes.

Policy Processes

According to Allison (1971), policy actions can be viewed as developed in three decision and organizational frameworks. These frameworks are:

— rational choice;

— organizational choice; and

— political choice.

Features of these frameworks are summarized in Figures 9.1, 9.2 and 9.3 (adapted from Allison, 1971). It is clear that, as the decision process moves from the rational choice to the political choice framework, the complexity increases substantially. The rational choice framework pays little attention to the governmental and related decision process. Goals of policies are posited, options are identified, consequences of the options are evaluated, and choice options relative to the goals or objectives are made. No consideration is given to delineating the goals, defining the options, presenting the analysis of options or making the choice. The governmental decision process is, in fact, a "black box" and choices are viewed as made in a highly stylized context. This is the model of government action that many economists have had in mind when developing policy analysis to support government policy choices.

The second model is organizational. Here, the features of the organizations that participate in the policy process become important. These organizations have goals and standard operating procedures and programs of their own. Policies are viewed within the context of the different organizational frameworks. The result is "factored problems and factionated power." Goals are defined but in the context of the organization. The same is true for performance standards, operating procedures and other factors contributing to the policy decision process. At the same time, a number of the characteristics of bureaucracy enter the framework. These include previously established priorities, uncertainty avoidance, central coordination and control, and the personalities of the leaders of these organizations. No longer does the decision problem have a clear set of objectives, options and consequences. Choices are negotiated and, in fact, decisions are more governed by standard operating procedures within these organizations than by the rational choice framework.

In fact, the organizational framework can be viewed as one in which there are a set of organizations with lives of their own and each with its own rational choice framwork. Of course, the rational choice frameworks of these organizations are not identical. Consequences for policy decisions include the importance of the organizations and the trade-offs between the organizations as important features determining policy outcomes, structures for coordinating these organizations, such as long-range and short-range planning, leadership within the organizations or hierarchies developed around organizational power and, generally, much less flexibility and more complexity than in the rational choice framework.

The third option or policy framework is political. Here are both individuals and government organizations with their respective choice frameworks. A consequence of this approach for studying decisions is that government decisions become almost entirely political. Organizationally, the players or agents assume particular positions; parochial priorities and perceptions are identified with the players (organizations, individuals or governments); political stakes and standards are important in the negotiation process; and finally, roles and conventions for action are developed. An analogy for the

FIGURE 9.1 RATIONAL CHOICE AS A POLICY FRAMEWORK[a]

Policy-making structure	National government The black box positive weighting of options against goals or objectives
Basic unit of analysis	Governmental action as the choice
Organizing concepts	One decision maker The problem Rational choice determines action Goals and objectives Options Consequences Choice
Dominant inference pattern	Government makes the choice
General propositions	Substitution effects are important in weighting consequences or objectives against objectives

[a] Adapted from Allison (1971).

FIGURE 9.2 ORGANIZATIONS AND ORGANIZATIONAL STRUCTURE AS A POLICY FRAMEWORK[a]

Policy-making structure	National government Leaders (Organizations and Organization Heads) Organizations Organization-specific goals Standard operating procedures (SOPs) Coordinating mechanisms
Basic unit	Governmental action as organizational output
Organizing concepts	Organizational actors (the constellation of which is government) Factored problems and fractioned power Parochial priorities and perceptions Choice as organizational output Goals: constraints defining acceptable performance Sequential attention to goals Standard operating procedures Programs and repertoires Uncertainty avoidance (negotiated environment, standard scenario) Problem-directed search Organizational learning and change Central coordination and control Impact of organizational leaders
Dominant inference pattern	Governmental action (in short run) largely determined by SOPs and programs Governmental action (in longer run) affected by organizational goals, SOPs, etc.
General propositions	Organizational hierarchy Organizational structures Limited flexibility and incremental change Long-range planning Goals trade-offs Imperialism Attention to administrative feasibility Coordinating committees or boards Consensus blue ribbon committees

[a] Adapted from Allison (1971).

FIGURE 9.3 PLAYERS AND POLITICAL ENTITIES AS THE POLICY FRAMEWORK[a]

Policy-making structure	National government Players and positions Goals, interests, stakes, and stands Power and power brokering Rules of play
Basic unit of analysis	Governmental action as political resultant
Organizing concepts	Players and positions Parochial priorities and perceptions Goals and interests Stakes and stands Deadlines and changing issues Power Action-channels Rules of the game Choice as political resultant
Dominant inference pattern	Governmental choice is the resultant of bargaining
General propositions	Political resultants Action and intention Vested interests Where you stand depends on where you sit Personalities and leadership Majority rule Inter- and intra-national relations Misperception, misexpectation, miscommunication, and reticence Styles of play and gamesmanship

[a] Adapted from Allison (1971).

latter, albeit a far more structured one, is the adoption of roles and conventions in advisory proceedings in administering the law. Policy actions are more a result of bargaining or political horse trading than a consequence of an overall rational choice process. Majorities are important, miscommunication and misrepresentation become valuable in the negotiation process, dynamics of policy play are important and, more generally, the political factions and their relative strengths are the ultimate determinants of policy outcomes.

Policy analysis processes

Clearly, the policy analysis processes that develop depending on the different policy paradigms are quite different. The rational choice framework, indicates a policy analysis process that is relatively conventional by traditional economic standards. Some general sets of objectives or a utility function is determined. Analysis based on an economic concept of the structure of the decision process is produced, choices are recommended or evaluated, and the outcome is determined. In this process, there is no recognition that the choices of models and developments of options are important in determining policy outcomes. In fact, the policy analysis process is viewed completely in a positive context. That is, normative judgments of economists and the agencies in which they operate that are made in evaluating options and articulating goals or objectives are not viewed as factors in policy decisions.

For the organizational framework, the policy analysis and the orchestration of policy analysis becomes more complicated. Here, the organizations are all-important. Policies and policy analysis are conducted within organizational structures. Of course, long-term and short-term plans are developed to help coordinate activities within and across organizations. Still, however, when the decisions are made, they are predetermined by the objectives and procedures or operating traditions and special constituencies. Thus, they are likely to view policy problems differently. These different perceptions suggest different approaches to policy analysis. Plans and priorities set by coordinated efforts control the kinds of analyses organizations develop. However, organizations develop policy analyses not for the problem at hand alone but to position themselves relative to each other. In short, the organizations are entities learning and changng through the policy process. Central control of these organizations is imposed by various methods and structures and leadership in the organizations is critical to policy outcomes.

Of course, the different organizations spawn different policy units. These policy analysis units are directed by the organizations and perceive policy problems relative to the priorities of the organizations (Buchanan, 1965; Cybert and March, 1963; March, 1965). Negotiation between organizations is a basis for policy decision. Results of the analyses must support the policy problem as perceived by the organization. Also, standard operating procedures in organizations give rigidity to analyses they put forward for policy choices. The result is differing policy analyses, all correct, but proceeding from different views of the policy problem and from different sets of objectives. This framework and the analysis processes it generates is reflected in the debate on the U.S. 1985 farm bill. Different organizations are producing different types of policy analysis. These policy analyses follow from different goals and objectives and different perceptions of the farm problem, all of which can be rather easily understood by reference to the organizations generating them.

The final framework is less well defined than the previous two. This political framework is essentially an extension of the organizational framework and analysis of its impact on policy action is in initial stages (Becker, 1983). Here there are different types of players in the policy arena. The players are individuals, governments, organizations, and other entities with political power. Policy actions are determined politically. Power is of ultimate importance in the decision process. Policy actions are determined by bargaining and trades for political currency. There is a place for quantitative policy analysis in this framework. Those players with strong quantitative policy analysis can exert more power in the decision process. However, other features of the decision process are important for the design and development of quantitative models. These features relate to the political entities, the value of introducing misinformation into decision processes, styles of play of different participants, and other factors. Individuals that subscribe to the political framework often argue that quantitative analysis is not ultimately important but simply a card to play at the proper time in determining a policy action.

Observations

Quantitative policy analysis and the policy analysis process are important under each of the choice frameworks. Moving from the rational choice to the political framework may make quantitative policy analysis even more important. Solid and timely quantitative policy analysis, recognizing that policy formation and policy processes are determined to a large extent by organizations and political forces, can be important in narrowing the range for play. Consequences of alternative actions can be determined but must be evaluated from differing viewpoints. Policy perceptions and approaches to policy analyses are oriented to a large extent by the organizations and political constituencies. The world of the quantitative policy analyst is no longer and, in fact, never was clean, pure and totally analytical. The positive economic paradigm by which many policy analysts feel they operate long ago went out the window.

Strengths and weaknesses of available models and policy processes

A number of trends in policy modeling and in participation in the policy process in the U.S. and Canada tend to substantiate the observations in the previous section. Specifically, there is a trend toward decentralization of policy analysis. Whereas, in the past, most of the policy analysis for agriculture was provided within the agriculture department or ministry, there are increasing indications that this analysis base has been broadened. In the U.S., the Food and Agricultural Policy Research Institute, the Congressional Budget Office, the Office of Management and Budget, among others, are generating analyses of policy alternatives. To some extent, this activity is a function of the interest on the 1985 farm bill. However, to attribute of all of this policy analysis activity to the 1985 farm bill is to greatly oversimplify the situation.

The policy setting

Based on the different policy frameworks, the one appropriate for Canada and for many developed countries is, in fact, not the simple rational choice framework. Instead, the appropriate framework should include organizations and political dimensions. The situation is more one of generating policy analysis to support trade-offs and positions being taken by organizations and political entities. The strengths of these organizations in the bargaining process for policy resides ultimately on their capacity to document and effectively argue their positions. The positions taken are a function of organizational and political goals. The setting is then one where increased development of quantitative models for policy analysis may occur. But it will be important for these models to anticipate bargaining positions of other parties to the policy process. This implies models that are broader in scope than those now operated within agricultural ministries and departments. To gain an edge in the bargaining process is to anticipate an opponent's overtures and to provide solid quantitative analysis supportive of a position that can be accepted but that is advantageous to the ministry or agency represented.

Failure to recognize the changing policy setting and the element of this policy setting can result in a weakened bargaining position for agricultural ministries and departments. Unfortunately, momentum and tradition are not on the side of opportunist actions by agricultural ministries and departments. Organizing and operating policy units to preserve the past prominence of the ministries in setting policy will be difficult. However, if agricultural ministries and departments continue to pursue narrowly defined policy analyses and are not responsive to the demands of the organizations within which they operate and the organizations with whom they compete, then they will continue to lose effectiveness in the policy arena. This holds not only for the policy analysis units and the policy analysis modeling processes but also for the ministries themselves.

There is no substitute for understanding the environment in which policy is developed. Those who recognize this environment will position their analysis and their resources to take advantage of the situation. Those who do not will find themselves playing in a game they do not understand, with obvious consequences. Thus, if the present hypothesis on the evolution of the policy framework is correct, agricultural ministries and their economic analysis units have large tasks ahead in reorienting themselves and recognizing their roles in the interorganizational malaise in which policy is developed. For the organizational and political frameworks, this reorientation involves positioning the analysis units to provide outputs that can help to dominate the long-term and short-term planning processes, the policy play and other structures that evolve to orient competing organizations toward common goals.

Policy analysis models

Agricultural research units and agricultural policy models have been oriented almost totally toward agriculture. Thus, agricultural ministries and departments come to policy debates not well prepared to deal with the broad aspects of their policy proposals. Policies or programs that are good for agriculture are not necessarily good for the other industries or for the national economy. The crux of the quantitative policy modeling mission in this framework is to provide analysis that can contribute to longer-range objectives and continuity or to the development of political coalitions.

Where does this leave agricultural models of traditional types? The answer is not encouraging. While there has been a trend toward expanding these models, encompassing broader dimensions of policy problems, the focus has been almost entirely on drawing these expanded dimensions back to agriculture. This is "inside out" policy analysis modeling. While it is important to understand the consequences of actions proposed by others for agriculture, it is also important to understand the consequences of policies proposed by agriculture for other industries and parties to the policy process. Here, agricultural economists and agricultural economics units within agricultural ministries have been particularly weak. True, they have broadened the dimensions of policy analysis models. But have they lost sight of the policy game? That is, have they simply established broader models which are still focused on agriculture? Alternatively, they will have to reverse the focus, generating evidence of the benefits to other sectors of agricultural policies.

Proposed policy modeling system

What do these implications imply for policy modeling systems for Agriculture Canada? To me, these concepts are sufficiently novel and new that ascribing a specific design for a policy modeling system is difficult, if not impossible. Instead, these ramblings and ideas should be distilled to condense the important propositions that should underlie the design of the policy modeling system and policy models. Rather than develop these propositions in detail, they are simply listed. They overlap in a number of cases, and are not intended to establish any priorities. Clearly, they point to the development of policy modeling systems and organizations for the development of quantitative policy analysis that are different from what is now available. Trends in this direction are emerging in the U.S. and in Canada.

These are the points that should govern the design of policy modeling systems and policy analysis models:

- selecting a policy framework (clearly a stategy cannot be developed that will be effective unless the rules of the game are understood);
- broadening the capacity for analyzing the consequences of policy measures outside agriculture for the agricultural sector, narowly defined;
- broadening the capacity for analyzing the consequences of policies advocated by agriculture for other sectors and other political entities;
- recognizing that the policy process is dominated by the organizational and political frameworks and developing goals, aspirations and specific policy proposals for agriculture accordingly;
- understanding that there will be increased participation in the policy analysis arena and that this participation will come from other stakeholders in agricultural policy, many completely outside agriculture;
- developing organizational structures within the agricultural ministry that are more consistent with modern concepts of the policy determination process;
- using these perceptions of the existing policy framework to gain an edge in interorganizational or political bargaining;
- recognizing that policy analysis and the policy decision process is evolving, and being flexible with respect to adjusting organizational structures and modeling capacities;

— understanding that policy debate is strongly influenced by quantitative analysis; and
— escaping the naive view that economics is positive, and recognizing that we all have objectives and perceptions of appropriate policy outcomes and that these factors influence our analysis.

The latter point is the only one that will be elaborated. The fact that economists have and will continue to be responsive to the units and organizations that support them may come as an unpleasant surprise to some, particularly those in quantitative policy modeling. However, a better understanding of the policy framework and the place of policy analysts and analysis units in it can serve to expand the horizons of economists and others who participate in the policy dialogue and debate, permitting more effective representation of the constituencies that support the organizations.

Conclusion

To a major extent, the conclusions of the critique in the foregoing observations have been anticipated perhaps all too frequently. Economics, which has typically not recognized organizational and political processes, is at an important crossroad in policy analysis. Perhaps it is because the micro foundations and, in fact, the major theoretical foundations of economics are individually oriented. Organizations need to be understood as important entities in policy making. Political processes need to be recognized as integral to policy formation, design and evaluation. And finally, the scope of policy analysis designed by economists needs to be greatly expanded and, more importantly, reoriented. We can make our policy models better, as suggested by the specific critique of the six policy models and the laundry list. But the problems that agricultural ministries and departments are facing in the policy process are certainly not all related to technical inadequacies of models.

As economists, we have tools and analytical and statistical skills that are advanced compared with these of other social scientists and, in fact, other participants in the policy process. These skills and capacity for analyzing data and providing quantitative inputs to policy debates and decision processes should give the profession as well as the agricultural ministries and departments an edge in the policy arena. This has not been the case recently. To ignore our inadequacies and the trends that are occurring in the decentralization of policy analysis would be a great mistake. Agricultural ministries need to overcome their bureaucratic momentum and tradition, recognize explicitly the nature of the policy game, understand more fully competing objectives of other stakeholders in the policy process and fashion an approach to policy formulation and policy analysis that is more consistent with the present economic and political settings and the more modern policy choice frameworks.

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10

Panel Discussion: Priorities, Capabilities and Recommendations

Introduction of panel speakers and comments

Douglas Hedley, Agriculture Canada

I would like to begin by introducing the panel to you. You have, I think, a relatively broad range of experience and capability and perspective on your panel this morning. Beginning on my far right, Hartley Furtan, from Saskatchewan. I think what we are looking for from Hartley is to bring to us a University perspective in modeling and in particular the use of models in policy. Next to me is Bruce Huff, who is I think well known to all of you and who is largely responsible for putting this seminar together. Bruce is head of the Commodity Market Analysis Division in Agriculture Canada and essentially is faced with serving two masters. He is responsible for the delivery of policy information to a minister, as well as for trying to service an operational program internal to the branch in which he works. So I am looking forward to the perspective he brings. Third, we have Klaus Frohberg from the International Institute of Applied Systems Analysis in Austria, bringing to us, I think, a very large amount of experience in a wide array of country models. He is attempting to bring these models together in usable form in international trade policy and serving a broad range of clientele, both international organizations and the member governments. That perspective from outside government, yet serving government clientele, is a very important one.

I would like to begin before these panelists get started with a few comments of my own that underpin the importance of the kind of deliberations we are having at this workshop. Models are really a tool that serve us. They serve a whole range of people, and Professor Johnson outlined a number of these clients earlier. We have to ensure that those models continue to serve clients, otherwise attrition sets in relatively quickly, not only in the model, but in the resources dedicated to them. I also want to make some comments about the importance of it now. The agriculture sector, for several decades was largely divorced from the rest of the Canadian economy. It operated within decision sets made within the sector, both provincially and federally. Policies were established primarily by a minister of agriculture or in consultation with his provincial or federal colleagues. Today we do not have that luxury. The agricultural economy is largely transparent to the domestic economy as well as to the international economy. As a result, I think we have to begin to recognize this interaction a very great deal more than we have had to in the past. I would like to report, for example, on a study in USDA by Stahlings and Shane. This study indicates the magnitude of the impact on U.S. farm exports to be expected under various assumptions about debt burden in the Third World. To maintain current growth levels in U.S. farm exports, debt levels in the Third World would have to grow more than fourfold before the end of this decade. Yet the capacity to even maintain existing debt levels is heavily dependent on currency exchange rates, commodity prices in agriculture and other resource sectors, steel imports to the developed world from the Third World and the like. These interrelationships which fundamentally affect the health of both producing and trading components of agriculture will continue to grow in their importance throughout the remainder of this century.

The North American agricultural economy was based for a hundred or a hundred and fifty years on an essentially low or no tariff level, while as the industrial sector was protected with relatively high tariff rates. We saw some growth in protectionism in the 1930s. That was largely whittled away in the various GATT rounds in the 1950s, the 1960s, and 1970s to the point where agriculture is relatively exposed, in the Canadian content, amounting to about 70% of all produce leaving farms. The proportion, I suspect, is not that much different for the United States. The great difficulty is that, as we move to reduce the existing trade barriers in agriculture, we may have to look at trade-offs within the industrial sector, simply because there are not that many trade-offs left in the agricultural sector of Canada. As well, there is the growing recognition through the OECD and the GATT that domestic policies may be the source of considerable imbalance between supply and demand in agricultural products. As a result, we may be led to laying domestic policies on the international negotiating table if we are to make progress toward a more open trading system and to avoid having some countries exporting the instability within their own agricultural sectors into the international market. Agricultural policy models that ignore the existence of the remainder of the economy, both domestically and internationally, including the goods and service sectors outside of the agri-food system, are not going to be of much assistance in the delivery of policy advice to senior officials, ministers and international organizations.

I want to comment briefly on the use of resources in modeling. We have to serve our clientele by knowing them and knowing them very well. We must recognize the institutional structures within which those models are built, and know that models serving operational programs on a day-to-day basis are different in design and operation from those serving the policy side. The flexibility and response time required in models in an unpredictable policy environment is different from the use of models in a continuing operational setting, which involves knowing deadlines for publishing information coming from those models. Our policy clientele controls the purse strings and the resources we have for modeling in the delivery of policy advice. I think we have to learn how to serve them well and Professor Johnson has offered us at least a different paradigm on how we serve the clientele controlling the purse strings.

My final comment this morning is on databases in modeling systems generally and specifically with respect to the development of the FARM model. We were well into FARM Model development before we began to realize the critical importance of the establishment and operation of a database. I think we increasingly have to look at the means of establishing a database more general than that required for the specific model to which it may be directed. We have to maintain the database in a way that presents alternate uses, not only for one very specific model, but also for a much broader range of models. In that regard, we have to explore within the context of modeling its hardware and software dimensions. This includes the backup software that runs the databases, the estimation systems, and the report writers as well as the software capability to download systems to make them as user-available as possible.

With those comments let me turn to the panel. I would like to start on my far right with Hartley Furtan, talking to us from the perspective of the university.

The perspective of the universities

Hartley Furtan, University of Saskatchewan

Thank you very much. First of all, Mr. Chairman, I would like to take this opportunity to thank Agriculture Canada, Bruce Huff, for inviting me and all the rest of the individuals here. It has been very useful and interesting and I hope that this process will continue in the future for others as well.

First of all, from a university perspective, it is easy to be a critic, a cynic of policy models, so I am going to try and avoid that, albeit not totally. When I came to this conference, I was expecting to find out more about policy modeling and my impression is I have learned quite a bit about models, many of which I have seen before. But I still wonder whether we are substituting modeling for economics. I guess, from my perspective and policy in Canada — agricultural policy — I still have that deep-down concern that we are substituting the model-building process for a basic understanding of how the economy works and how it is organized. I do not think it is any secret that the main beneficiary of the models is model building and, that is good. But what we tend to find is that policy makers themselves are too busy, they don't have time to build models, so it is left to other people to build models. As a consequence, there is a communication gap between users and model builders, partly because of the way we have designed our profession. I do not know of any particular way to overcome that, but I think that we need to closely examine whether or not we are giving up too much of our economic understanding for the model-building process. That is one of my major concerns.

Another concern I have is for large models versus small models, but I do not want to get into that debate as I do not know much about it. But from my perspective, I have always liked small models that I can understand. They are easier to explain, but there have been other advantages in that I can send them to my colleagues anywhere and have them criticized. When you get larger models, it is much more difficult to do that. When we look at the models here and go over them fairly fast, I am not sure how much understanding we are able to transmit, simply because of the scale of them and the difficulty to see what is going on.

From a university's point of view on this, I think we have to recognize that Canadian universities are fairly small. Our resources are fairly limited in agricultural economics, and we are not likely to be able to make a large contribution to Agriculture Canada or to the Bank of Canada in policy modeling, unless we take this other approach where things are smaller and we rely more on basic understanding of economics.

Now I would like to say a few things about policies. This summer in western Canada, we had a fairly large and significant drought. One of the agencies, the PFRA agency, has over time developed a drought model and they have a lot of very creditable people developing this model. Unfortunately, it was not very useful for the short-run policy analysis in giving policy advice. And I think that tells us something that we need to know when we look at policy. We need to be sure that the model we have is able to provide reasonable advice fairly quickly, because policy makers are not going to sit around and wait for an answer.

Finally, my area of interest in economics has to deal with such things as science policy or policy regarding regulation, institutional change, or policy regarding such things as the depletion of our soils, if in fact they are depleting. I fail to see how these models are going to help me in my understanding of these problems. Maybe it is just my ignorance that I do not understand the models well enough. But I am wondering if we have not taken too narrow a view in our investment in these models to look largely at forecasting and large sectors without first of all asking the question, What policy are we trying to answer? I think that relates to what Stan Johnson said this morning about our need to take a little different approach to this idea or process of policy modeling. From a university viewpoint, I think we can help by bringing some of the expertise to you about regional problems and also, from a theoretical point of view, our understanding of how our industry works.

The perspective of government

Bruce Huff, Agriculture Canada

Our panel appears to agree on a number of things, so perhaps there are some useful common threads in our conclusions. I would like to reflect on what has been discussed over the last day and a half and to talk as well about some of the management issues that I face when I try to draw upon models in order to provide policy information to decision makers in Agriculture Canada.

Let me start with some reflections from yesterday's presentations of the six models. Each of them had a slightly different set of strengths and abilities to respond to the information priorities that we outlined at the start of the workshop. Each has different degrees of complexity, and require different types of data. They have different support requirements for operation and they are in quite different stages of development. However, it was not until this morning when we had Stanley Johnson's "laundry list," and critique that we had an intensive look at these different models. We need to use a subset of that laundry list to undertake a more formal review of these models. Also needed is an evaluation of the priorities in terms of model development from Agriculture Canada's point of view at least. If the information priorities are appropriate, then there are some other concerns about the structure of the models. I think that the next step should be a more formal review of how these models rate within these criteria and information priorities.

I would like to describe briefly the operating environment and the manner in which models and model results are used in the Commodity Markets

Analysis Division. Much of the material is contained in the appendix to the paper on policy information requirements, which was presented yesterday. Some of the mechanics of the policy analysis process was described, including how the information flows from analysts to decision makers in government. For this purpose, a case study was made using the grains unit. For this case study, we identified what types of requests were received and how responses were made with a view to making management decisions to improve the operation of this process. There were 253 written responses to requests to the grains unit over a 21-month period, or approximately three a week. A number of these were updates on outlook, suggesting that staff needed to keep up-to-date on the outlook for their particular area. Some of these responses were comments and implications of memoranda to Cabinet prepared by other departments. Generally, there is a very short time frame available to respond in essence to the analysis of others. Twenty-six requests were simply to provide background to senior management, usually for a speaking engagement or a visiting delegation. Of the remaining 145 requests, there were probably three substantial policy issues, which involved 59 written responses. These included Domestic Feed Grains Policy, the Feed Freight Assistance and the Western Grain Stabilization Act. Now in those three areas, better analytical tools would have been very useful in reaching a decision or perhaps a better decision. For two of those cases, the Domestic Feed Grains Policy and the Feed Freight Assistance, when the analysis was requested it did not appear that there was sufficient time to develop a quantitative analytical procedure nor to modify existing models. In hindsight, time was available since the decisions were delayed or reappeared. Nevertheless the environment in which we operate rarely provides good information on when a political decision is going to be made.

In most of the other cases, of about a hundred written responses, there was neither the time nor did the issue warrant extensive analysis from the development of a model. In the case of the Western Grain Stabilization Program, however, we did develop a small model to analyze the program's mechanics and funding requirements under a fairly narrow set of alternatives to the existing policy. In conclusion, a large majority of the cases had a response time of only one to three days. This implies that, for most of the issues to which we responded, there is little time other than to use coefficients or multipliers that may be available from a model. In a small number of cases a model could be operated or perhaps even modified to respond to a particular case. In maybe two cases, there would have been time to build a model if we had recognized the time frame that was available. I think this implies that the multipliers and coefficients from models are very important, but they must be sitting on your desk or within easy access. It also implies that, if we are going to use policy models for particular issues, we must anticipate priority issues and when they are going to require analysis. Based on past experience, that is sometimes difficult to do. Perhaps we must do a better job of anticipating when particular markets are going to face problems. That may be an easier task than trying to anticipate when decision makers are going to feel some pressure to act. It is important to recognize that there is a particular environment in which you are operating which must be reflected in model development and operation.

I would like to comment on the issue of model scope. There seems to be some similar concerns raised from several individuals this morning. I was interested in Robert House's comments on model size and the resources commitments in the USDA. He indicated that it was a very small group assigned to the operation of models to respond to policy issues across the whole series of USDA models. An issue raised by Hartley Furtan was that models are useful to examine the linkages across a broad spectrum of variables, and to incorporate time lags. We may be focusing our models to include too much detail. Perhaps we should try to focus somewhat more broadly and capture only those major linkages and then draw on other types of information sources for some of the detail. Modelers tend to view larger models as better models, without recognizing the full cost of building a large model. It is not only the development cost that must be considered. This is the tip of the iceberg. There is a continuing maintenance and operation cost. There is also a cost of trying to convey to decision makers the results of that model, and a complex model is not as transparent as smaller, simpler versions. So, we need to seriously reflect on how large a model we need for particular problems.

Another important aspect of models, raised by Stanley Johnson and Hartley Furtan, is whether the types of questions we are posing are too narrow for our models. In Agriculture Canada, this reflects on our organization and it is unlikely we are unique in this regard. Several years ago a reorganization grouped economic researchers into much smaller units, closer to program and service activities. Thus they would be more relevant by working closely with the people who dealt with the real-world day-to-day problems. As a result, they have been organized in fairly small compartmentalized groups. The questions those groups are asked reflect their abilities to deliver—in this case—a single commodity or subset of a commodity. To get an appropriate breadth of analysis requires a linking of several of these groups. Experience has shown that trying to organize a cross-organization group on a research project is extremely difficult.

I would like to make some comments on the data issue, also raised by Douglas Hedley. We have recognized in our forecasting models that data management is the key to their successful operation on a quarterly basis. Some time ago, we concluded that we would not be able to deliver quarterly forecasts if we could not have our data system well structured. We spend quite a bit of time ensuring that a data system was well organized, that people were responsible for maintenance on a regular basis to ensure its timeliness, and that there was adequate quality control. It was also available for other uses. As a result this was one of the factors contributing to the success we have had with our large quarterly forecasting model. As for the models discussed yesterday, there is quite a difference in the data requirements of those models. In some cases, we are looking simply at time series data to which we already have access by and large, and getting it is a matter of organization. In other cases, we are looking at some cross-sectional data that is up-dated periodically, but which is very expensive to get. That makes a difference to the cost of the model. Those models for which there is not a good historical database become a very costly part of the whole process. Despite the utility of those models, the cost of simply obtaining the data and operating these models may preclude their actual operation. This is another reason why we may need to reflect and have a much smaller model. Having a good database allows us to have some flexibility in models which is essential for working in the government environment which requires quick responses. Often the questions are not posed neatly, so an existing model needs to be adjusted. Hence, having a good database may allow that type of flexibility.

The question of institutionalization of models is also important. We have not had much success in terms of institutionalizing models that have been developed outside Agriculture Canada. If we are going to use our modeling resources effectively, we must develop models that are used more than once. These cannot relate to one individual, but rather to an institution. This avoids the criticism that models are only useful to the modeler who developed them. I think we have seen some, for example, the FARM model, which has been institutionalized; then when new staff are hired, they have a tremendous tool to augment their capabilities to do policy analysis and outlook.

The perspective of IIASA

Klaus Frohberg, IIASA

This is the first time I have been exposed to a presentation of the very impressive set of models dealing with Canadian agriculture and other aspects of the Canadian economy. I am very interested to see whether Agriculture

Canada makes an effort to make these models complementary. Some of these models stand on their own; however, each can contribute to the others across these models. I would suggest Agriculture Canada invest some of its resources by making more complementary use of the models. I am especially impressed by the quality of the models, knowing what is available in other countries.

As you know, we surveyed models in quite a large number of countries and we have searched around to see whether we have to do the job of modeling the agriculture sector or whether we can rely on other models available in the country. There were basically only two countries, the U.S. and Canada, which were able to help us. The other countries, especially amazing to me, to some extent neglect the modeling of the agriculture sector for the purpose of policy analysis. There are some models around but they never get off the ground to really be used, for several reasons. The most obvious reason is that these models are not trusted by those who should use them. This brings me to another problem: how do we, the modelers, effectively communicate with the users of the model. Hartley Furtan mentioned it and it was also brought up several times during the meeting. We are more trained in estimation of economic parameters, but we have to train ourselves in effectively communicating with the politicians. The models themselves might be very good, but they are rejected very often because of lack of understanding of their intrinsic characteristics. The politicians are stuck with saying they will not use them unless they know what is generating these numbers. This is certainly a field of self-education for many modelers. This is, of course, a self-criticism as well.

The models available for Agriculture Canada cover quite a large field in their characteristics. The models are all dynamic, some of them run in quarters, and some of them in annual time increments. The models have different time horizons. They are more oriented to the short term, although they might run on annual time increments. You may need a model more oriented to the long term with a regional breakdown to compare with the national level of the other models. You have really a wide scope in models which, effectively used, could really give you a good picture. But I admit I do not have the recipe for how to integrate these models.

I should perhaps say a word about validation of models. This word was not even mentioned once during the one-and-a-half days. Validation is of course one of the biggest problems we face, especially with large-scale models. The formal validation processes are written up in literature but, for large-scale modeling, there are not many approaches. There is some scope for improving this should some of you be interested in doing so. But more than the formal validation processes I think the informal validation processes can help to bring the highlights of a model to the forefront. The informal validation process is really the one which is needed to convince those who have the say whether a model will be applied or not. For the purpose of our validation processes, we have gone through a few rounds of expert meetings. We are in the fortunate situation where experts from the various countries come in and simply sit down, look over the printouts and give their comments. This is perhaps the most effective way of getting corrections. At the same time, we try to convince those who are in a position to judge whether a model works as it should. I should, however, stress from my experience that a single number can make your model bad or good.

This is another conflict I cannot solve. I think single numbers, although they are very important, should not be the overriding concern for judging a model. But my experience in validating the models in that way has been very painful. In addition to communicating between the colleagues in our own field, we need communication between the model and the users of the model.

Yesterday when I had the floor, I said there are some pressing issues for modeling for policy analysis which really have to be improved. For the sake of getting them on the record, I would like to just touch again on some of these. One of the most important problems is the identification of the structures. The micro foundations of the implications of the structure should be brought out. The policy process should be modeled. I thought the organizers of the meeting should have given Stan Johnson more time to talk about modeling policy processes, because this is really where we do not have any knowledge. I would recommend that we look a little bit beyond our profession and try to integrate some political science or other knowledge to overcome this really big basic problem in our policy analysis, or modeling for policy analysis.

Another critical point is the representation of technical progress in the model structure. I could summarize this idea by saying modeling for policy analysis should not include the time variable. The time variable is always an approximate representation of anything we cannot capture in the structure. If policy modeling has an effect, it might indeed also change what you implicitly represent by a time variable. A recommendation to those who model policy for policy analysis is to get away from using time variables in your model. There is a lack of communication between the modelers and the statistical offices. I have myself been only once to a meeting where statistical officers brought together some people who model for various purposes and asked them what data they needed. Perhaps we should be more active in going to the statistical offices and telling them what kind of data we need for our policy models. In the IIASA approach, we generate a limited amount of information which is missing. This is also a dangerous approach when one tries to do this for a large set of data.

Lastly, on the issue of linking the farm and nonfarm sectors, I was very interested in the linkage of the monetary sector by Robert Romain. But one perhaps has to go further than the more simple IS-LM approach and try to look into more structural specifications of this as well. But I think this was a very good first approach. I would like to see our work extended in this direction as well.

Comments and closing

Stanley Johnson, University of Missouri

I would make one general observation for the USDA and Agriculture Canada. Four or five years ago, the USDA was instrumental in organizing a set of annual conferences on modeling, which ranged over a wide variety of topics. As a person participating in those conferences, I found them extremely useful for university faculty members to get a better understanding of the policy arena and what policy topics were current. Those conferences spawned a whole array of good policy analyses in the U.S. and involved university staff in policy analysis much more actively. These conferences stopped for reasons that are not clear to me. I would encourage reestablishing them, with cooperation between USDA and Agriculture Canada.

This is the first meeting that I have been to for a while that has been focused on policy modeling. We found ourselves sometimes in no-mans-land, discussing very specific structures of models, rather than modeling techniques, as well as the design of modeling systems and policy analysis processes. If we are going to have future policy modeling conferences, we might concentrate on particular technical features of models, for example, how to model supply response for grain commodities. For that topic, university people can contribute effectively on micro foundations and theory. In contrast, those who are creating large models can review the work in applied forecasting and policy exercises. By narrowing the scope of the conference and mixing applied or operational and theoretical approaches to specific policy problems, you can provide a conference that is very valuable.

Klaus Frohberg made the point that we have had conferences on modeling technologies, but we did not touch on this subject much at this time. There are hosts of questions on validation of models. How you position models relative to other models can be very useful. For instance, there has been great integration of time series and econometric methods. Many agricultural policy modelers in the past estimated structural models by curve fitting to get them to predict well. There is no reason for curve fitting any more. We know how to solve the prediction problem and we should stay within the context of the theory in model specification. Finally, there is room for a conference on positioning the whole policy analysis process. Understanding the policy game that we are playing is fundamental to organizing how to play it or developing a strategy for playing it. We are not doing a very good job of anticipating policy problems and positioning ourselves relative to these problems. Bruce Huff has eluded to this problem. Bob House's comments were useful in this area also. We just do not have very good mechanisms for evaluating whether our policy analysis is any good or not. We do not have a structured feedback mechanism. It is strange that people so good at quantitative analysis and framing decision problems, when it comes to framing the decision problem that really governs their resources, have not thought much about the process. Yet the management of a policy information base is very tractable.

Klaus Frohberg, IIASA

I would just like to make a remark to your last statement. IIASA indeed once took the role in organizing annually a conference on global modeling. We did it for 10 years, I think, and then thought it had explored the whole range of issues, so it was stopped. But perhaps stopping was more a matter of financing problems than anything else. There is an institutionalized set of meetings on energy modeling going on regularly. These meetings are sponsored by Stanford University. Specific policy and technical questions are put to all modelers and they come together with their answers and then they try to informally unify or come out with an agreed answer on the major problem of a conference. I am not advocating this approach but rather, along the lines of Stan Johnson's suggestion, having more meetings of this kind.

Kirk Hamilton, Statistics Canada

I would like to pick up on Klaus Frohberg's last comment about the relationship between statisticians and modelers of modeling activities. There is, in fact, now under reorganization at Statistics Canada, an analytical services branch whose job it is to make use of the great variety of data within Statistics Canada and to provide a variety of services on modeling to the policy community. There are people working in economic modeling areas, social models, social statistics as well as resource models, the particular interest in my division, Structural Analysis. Our reason for coming to this conference was to be exposed to the variety of models used in the policy areas. Our particular interests are in the resources, looking at land as the ultimate resource of the agricultural system, conflicts involved in different land use patterns, the ultimate environmental effects of different cropping practices, and so on. So I did want to point out that, at least within Statistics Canada, the current thinking is that we do have to recognize the need for closer ties between modelers, policy analysts and statisticians, and we certainly invite interest from the research and policy analysis community on these issues.

Robert House, USDA

I just have some comments or reactions to the discussion of this morning. I think a number of research services have had some difficulty in receiving the product wanted when organized around fairly large-scale modeling. That is what happened over the past couple of decades. Right now, we are probably running a bit more of a shoestring operation than we would like, but there has been a management reaction against big modeling teams. The shoestring operation seems to be working reasonably well, but you wonder how long people can continue or want to continue in that environment. Another consideration is the objective of the model building. We all received most of our formal technical training in the academic environment, even in an applied discipline like agricultural economics. Thus, the objectives of many of us are aimed at something publishable in professional journals and that makes it tough to have the courage to build a simple model.

I talk to people in our crops branches and animal product branches and they are doing very interesting and sophisticated research. When I ask them what they are doing, they say policy analysis, and I wonder what decision maker is going to really benefit from their work directly, unless somebody interprets it or does something with it in between the analyst and the decision maker.

I have one little note on institutionalization, which I feel is important for mathematics programming, perhaps less so in econometric modeling because more of it is done. That is the issue of higher-level modeling languages. We have, for example, with the math programming I have worked on, several different user interfaces. Right now, someone who is going to get into that area of our operation, they first has to understand basic economic theory, the data and the agriculture sector. Then he or she has to become familiar with, say, 6,000 lines of Fortran and learn to work with a computer system. It gets a little more demanding with nonlinear optimizers.

Fortunately, there do exist new high-level modeling languages in which one can work in economics rather than in Fortran. If we can push in that direction, people can be brought in who can understand the theory, the data and the economics. We do not have to worry so much about these other things like programming and computer programming which are just nuisances. We have this problem in the Economic Research Service of USDA. I do not believe we have been able to ask the computer programming staff to support our modeling efforts directly. In most cases, the analysts and model developers have to do a lot of programming themselves. And, it is not really the best use of their time. If we can move toward higher modeling languages, we can be more productive and happy doing quantitative analysis for a longer period of our careers, rather than eventually burning out and wanting to do something else.

The last thing I would encourage is linking math programming and econometrics. We really have the technology to do this now. It is not all that complex with the optimizers that are available. We can truly incorporate nonlinear functions in math programming models. This may seem to increase complexity. But with these methods, you can take many fewer nonlinear activities, a very small tableau but one can do a lot of things. This means that you have a smaller database to work with and smaller data files. Certainly, there is increased computation in nonlinear optimization, but it is a method to bear more of the tremendous econometric talent we have and the discipline in math programming contexts.

Brian Davey, Agriculture Canada

I would just like to make three points. The first one is that this is the second meeting of this type I have attended within the last 18 months. The first one was a small symposium on the use of quantitative models in agricultural policy analysis that was part of the annual conference of the Agricultural Economics Society in the United Kingdom in 1983. That symposium essentially took the form of a number of people, I think almost exclusively from universities, presenting and discussing specific models. These models were built to look at a particular policy issue. When the project was finished, and the paper published in the journal, the policy model was thrown away. Then, apparently, one starts on the next topic that is of interest. Here, there has been quite a different focus on more generalized policy models that one can use to examine a whole range or series of policy issues for government. This approach is valuable since, as Bruce Huff indicated earlier, we do not often have the luxury of the time required to build a specific model that may indeed be better suited to the particular issue we want to analyze.

The second point would be on the institutionalization of models. Bruce made a comment that it is very important to make sure that models are used more than once. I think we have to consider, sometimes, about not just institutionalizing models for use within government, but also how we can make the models that we have developed and are maintaining available to users outside government. My division in Agriculture Canada has had developed on contract a linear programming model of the meat packing industry in Canada that we think has application, not just for policy and program analyses within government, but also for use by the industry itself. I can tell you, if you are not aware already, that it is quite a challenge to interest the industry in picking up a particular modeling technique and using it.

The third point I want to make is that the way in which one presents the results of modeling work to the policy makers is critical. I am speaking from experience again. There is a tendency sometimes to present the impacts of alternative policy options in terms of a difference from a base run. This can lead to problems because the policy makers often overlook or forget the relativity point. In other words, if you present the results in terms of relative changes from a base run at some future date, you tend eventually to leave the relativity point out of your presentation, and your results can get misinterpreted. I am talking about our work in the Food Markets Analysis Division on the Crow Rate, where changes 10 years down the road, from the situation that would have prevailed had the Crow Rates been in place, were estimated for a range of alternative freight rate options. They were very quickly translated—despite all our efforts to explain the relativity point over and over again—and interpreted by a lot of people as absolute changes from where we were today. This experience had led us in the work we are doing now to make some changes to the way we present our results.

Kurt Klein, University of Lethbridge

The problems of getting our results interpreted properly and actually used in policy development is something we have been struggling with for many years. Some of us around this table were originally hired by Agriculture Canada for their Project 75, more than 10 years ago. And at that time, we made some fairly big efforts to bring agricultural specialists from provincial departments into our thinking process, because eventually most agricultural policies in Canada have to be coordinated with provincial policies. And I notice at this workshop, for example, there still is not a single person here representing a provincial department of agriculture. And I still see this as one of the obstacles that we have to overcome in Canada before we can actually get on with the job and make the models we already have more productive and more useful.

Stanley Johnson, University of Missouri

I feel that someone should pick up on the thought that was provided by several on the panel about data systems. Hartley Furtan was saying that the University people find it difficult to participate in ongoing policy analyses. One of the reasons is the high cost of acquiring the data and updating it. As a matter of fact, at Missouri, where we have an agricultural model, I would hazard a guess that at least a third of the modeling cost is related to kind of keeping the data up, making internal checks and so on.

I am on a committee of the American Agriculture Economics Association that is looking at modeling and ways of taking advantage of investments in modeling that have been made by the profession in a better way. For example, the T-DAM system at USDA really does not work very well. We were one of the experimental institutions that tried to use it. Two things happened: one, it costs a lot more to service than the USDA thought and was prepared to allocate to it and, two, it costs a lot more on the other end of the system than we thought. Nobody was wrong or right. It is just that a big system was put up and it is not being used very much by people out in the profession and, in fact, not extensively by USDA.

Agriculture Canada has a database that we have been trying to get people to use and it has not taken off. It is very curious to me why the database is not being used. As modelers and people interested in quantitative modeling, we ought to ask some hard questions about why these overtures have not worked. Various kinds of archiving and electronic transmissions of models are possible. The technology is here for data and model transmission. We need to systematically consider the problem and make available realistic levels of resources to do it.

Gerry Robertson, Agriculture Canada

I have a series of points I would like to make, somewhat unrelated. From my experience, it is advantageous to attack a problem from the output first. As modelers, we often think about building the model, running it and then writing the briefing. If you write the briefing first, you know exactly what numbers you want and you know exactly the format you want them in. It is very often a useful exercise to design the output first.

The second point, which most consultants know from day one, is that presentation matters, often more than 50%. If you are going to tell somebody some things, and you want to get paid for it, you spend a lot of time on presentation. We as modelers quickly forget that. I am being very critical of myself. We try to be academically or intellectually accountable by spending a majority of our time on the analytical part of the analysis. I think this gets a little bit to the point raised by Klaus Frohberg and other people that we need to spend more time on communication.

The third point is that there really is an informational technological revolution right now. Computer technology is now a lot cheaper. You do not have to worry about the cost of solving the model. This cost is infinitesimal compared with other costs. But the issue is broader than that. Policy makers can now use word processors, micrographics, and literature searches. They can get encyclopedias on line. In a very real sense, the amount of information that can be brought to policy issues is just phenomenal. The way we look at policy analysis should at least recognize this fact.

For output, we tend to think of policy analysis as being a briefing note or some input on a sheet of paper or even a meeting. There are a lot of options in output now for transmitting this output: electronic mail, distribution of the model through electronic mail or satellites, etcetera. We may have to change the way we look at policy analysis. The last point I would like to make is to agree with other people and state that, at least personally, I found this a very useful conference. I would strongly urge that we publish the proceedings, comments and discussion relatively quickly.

Douglas Hedley, Agriculture Canada

It being about 2 minutes to 12, I am going to stop the discussion at this point and thank you very, very much for your participation and thank the panel members for their contribution this morning. With that I will turn it over to Bruce Huff to close up the workshop.

Bruce Huff, Agriculture Canada

I have just some brief ending comments. I want to also pass on thanks to other people who participated very heavily in getting this conference going at Agriculture Canada and who worked as part of this organizing committee. We had a major input from Stan Johnson as well. I think all of us are quite pleased in how well it has turned out. When you start planning a conference, sometimes you wonder about the end result. In this case, all of the papers have been extremely good. We have written papers from every participant. It is unusual for a conference to have all papers ahead of time, and we would like to thank all of those who did make presentations. We sincerely appreciate the input and effort that you have made to get the papers in and the excellent job in presenting them.

To the other people who participated, I think the discussion was very good and very lively at times. We appreciate your coming and participating in the workshop. It certainly has exceeded my expectations in terms of results. I share Stan's suggestion that an annual North American conference on modeling might be initiated. I will be talking to Ken Clayton, USDA, to see if we can do something on a more formal basis to proceed.

Again, thank you very much for your participation and I certainly enjoyed your comments and papers. It has been a pleasure to participate during the past day and a half.